This document was too large to scan as a single document. It has been divided into smaller sections.

SECTION 1 OF 3

Document Information			
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DOE/RL-2004-24
DRAFT A
REISSUE

Feasibility Study for the 200-CW-5 (U Pond/Z Ditches Cooling Water Waste Group), 200-CW-2 (S Pond and Ditches Cooling Water Waste Group), 200-CW-4 (T Pond and Ditches Cooling Water Waste Group), and 200-SC-1 (Steam Condensate Waste Group) Operable Units

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2004-24
DRAFT A
REISSUE

Feasibility Study for the 200-CW-5 (U Pond/Z Ditches Cooling Water Waste Group), 200-CW-2 (S Pond and Ditches Cooling Water Waste Group), 200-CW-4 (T Pond and Ditches Cooling Water Waste Group), and 200-SC-1 (Steam Condensate Waste Group) Operable Units

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FIGURES

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TERMS

ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BCG	biota concentration guide
bgs	below ground surface
c/min	counts per minute
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CLARC	*Cleanup Levels and Risk Calculations under the Model Toxics Control Act Regulation* (CLARC Version 3.1) (Ecology 94-145)
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	CERCLA past-practice
d/min	disintegrations per minute
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FS	feasibility study
FY	fiscal year
GRA	general response action
HCP	*Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F)
HEDL	Hanford Engineering Development Laboratory
IAEA	International Atomic Energy Agency
IC	institutional control
ICRP	International Commission on Radiological Protection
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28
ISV	in situ vitrification
MCL	maximum contaminant level
MESC	maintain existing soil cover
MNA	monitored natural attenuation
N/A	not applicable
NCP	"National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300)
NEPA	*National Environmental Policy Act of 1969*
NPL	"National Priorities List" (40 CFR 300, Appendix B)
ORP	U.S. Department of Energy, Office of River Protection
OU	operable unit
PFP	Plutonium Finishing Plant
PIF	Plutonium Isolation Facility

PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction Plant
PVC	polyvinyl chloride
RAO	remedial action objective
RATDU	Radioactive Acid Digestion Test Unit
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
RCRA	*Resource Conservation and Recovery Act of 1976*
RECUPLEX	Recovery of Uranium and Plutonium by Extraction Plant
REDOX	Reduction-Oxidation Plant
RESRAD	RESidual RADioactivity (dose model)
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
RLS	radionuclide logging system
ROD	record of decision
RPP	RCRA past practice
RTD	removal, treatment, and disposal
SLERA	screening-level ecological risk assessment
STOMP	Subsurface Transport Over Multiple Phases (code)
TBP	tributyl phosphate
TEDF	Treated Effluent Disposal Facility
TMV	toxicity, mobility, or volume through treatment
TPH	total petroleum hydrocarbon
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and/or disposal (unit)
UPR	unplanned release
URM	Underground Radioactive Material (area)
WIDS	*Waste Information Data System*
WIPP	Waste Isolation Pilot Plant

METRIC CONVERSION CHART

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	Meters
yards	0.914	Meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries

CHAPTER 1.0 TERMS

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CPP	CERCLA past-practice
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28
NPL	"National Priorities List" (40 CFR 300, Appendix B)
OU	operable unit
PUREX	Plutonium-Uranium Extraction (Plant or process)
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (Plant or process)
RI	remedial investigation
RL	U.S. Department of Energy, Richland Operations Office
RPP	RCRA past practice
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UPR	unplanned release

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1.0 INTRODUCTION

The Hanford Site, managed by the U.S. Department of Energy (DOE), encompasses approximately 1,517 km^2 (586 mi^2) in the Columbia Basin of south-central Washington State. In 1989, the U.S. Environmental Protection Agency (EPA) placed the 100, 200, 300, and 1100 Areas of the Hanford Site on the 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan (NCP)," Appendix B, "National Priorities List" (NPL), pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The 200 Area NPL site consists of the 200 West Area and 200 East Area (Figure 1-1), which contain waste management facilities and inactive irradiated fuel reprocessing facilities, and the 200 North Area, formerly used for interim storage and staging of irradiated fuel. Several waste sites in the 600 Area, which is located near the 200 Areas, also are included in the 200 Area NPL site.

The 200 Areas consist of approximately 700 waste sites, organized into 23 waste site groups called operable units (OU). Four of these 23 waste site groups are the focus of this feasibility study (FS): the 200-CW-5 U Pond/Z-Ditches[1] Cooling Water Waste Group OU, the 200-CW-2 S Pond and Ditches Cooling Water Waste Group OU, the 200-CW-4 T Pond and Ditches Cooling Water Waste Group OU, and the 200-SC-1 Steam Condensate Waste Group OU (Figure 1-2). The 200-CW-5 OU, 200-CW-2 OU, and 200-CW-4 OUs are located in the 200 West Area. The 200-SC-1 OU includes waste sites located in the 200 East Area and the 200 West Areas (Figures 1-2 and 1-3) and received steam condensate from the Plutonium-Uranium Extraction (PUREX) Plant and B Plant in the 200 East Area and S Plant (Reduction-Oxidation [REDOX] Plant) and T Plant in the 200 West Area. The 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU waste sites lie inside the exclusive-use boundary (Core Zone) identified in DOE/EIS-0222-F, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* and shown in Figure 1-1.

The process for characterization and remediation of waste sites at the Hanford Site is addressed in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). The Tri-Party Agreement establishes major milestones for completing the waste site investigation effort by December 31, 2008, and completing waste site remediation by September 30, 2024 (Milestones M-15-00C and M-16-00, respectively) for non-tank farm OUs in the 200 Areas. In 2002, the U.S. Department of Energy, Richland Operations Office (RL), EPA, and Washington State Department of Ecology (Ecology) (the Tri-Parties) renegotiated the 200 Areas waste site cleanup milestones under the Tri-Party Agreement. The results of these negotiations are documented in Tri-Party Agreement change forms M-13-02-01, M-15-02-01, M-16-02-01, and M-20-02-01. As part of these negotiations, the Tri-Parties agreed, in Change Packages M-15-02-01 and M-13-02-01 approved June 2002, to consolidate the 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU with the 200-CW-5 OU for the purpose of remediation

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[1]The term "Z-Ditches" refers to the Z-Ditches Complex, which includes the 216-Z-1D Ditch, 216-Z-11 Ditch, and 216-Z-19 Ditch.

documentation and execution. The controlling milestone for the 200-CW-5 OU was M-13-22, "Submit U Pond/Z-Ditches Cooling Water Group Work Plan," dated December 31, 1999.

The Tri-Party Agreement also addresses the need for the cleanup programs to integrate the requirements of CERCLA and the *Resource Conservation and Recovery Act of 1976* (RCRA), to provide a standard approach to direct cleanup activities in a consistent manner, and to ensure that applicable regulatory requirements are met. Details of this integration for the 200 Areas are presented in DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (Implementation Plan). This FS implements the RCRA/CERCLA integration process presented in the Implementation Plan (DOE/RL-98-28) and the Tri-Party Agreement.

The 200-CW-5 OU consists of ten CERCLA past-practice (CPP) waste sites, two RCRA past-practice (RPP) waste sites, and three CPP unplanned release (UPR) sites. The 200-CW-2 OU consists of eight CPP waste sites and one CPP UPR site. The 200-CW-4 OU consists of seven CPP waste sites and one RPP waste site. The 200-SC-1 OU consists of 13 CPP waste sites and 3 CPP UPR sites. Thus, a total of 41 waste sites and 7 UPR sites are covered under this FS. Table 1-1 lists waste sites and UPR sites associated with each OU. The two 18-inch vitrified clay pipelines associated with the field investigation will be discussed as part of the 200-IS-1 OU. There is a recognition that these pipelines better fit within the conceptual models being developed by the 200-IS-1 work effort.

Within the 200-CW-5 OU, one of the UPR sites, 200-W-110, is moved from the 200-PW-1 OU to this OU, in accordance with the updated Tri-Party Agreement Appendix C package that is pending approval. The 200-CW-5 OU remedial investigation (RI) report (DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*) added three waste sites: the 200-W-84 Process Sewer, 200-W-102 Process Sewer, and 216-W-LWC Crib. The 216-W-LWC Crib or laundry waste crib has been reassigned to the 200-CW-5 OU from the 200-SC-1 OU following the Tri-Party Agreement procedure for waste site reclassification (RL-TPA-90-0001). The laundry waste crib is an RPP site.

The 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU waste sites received cooling water, steam condensate, and chemical sewer waste from several facilities in the 200 East and 200 West Areas. These effluent streams ranged from acidic to basic and carried chemical and radiological contaminants. Chapter 2.0 provides a detailed description of sources of contaminants, types of contaminants, and other waste-related items.

During the 200-CW-5 OU RI, data were collected to characterize the nature and vertical extent of chemical and radiological contamination and physical conditions in the vadose zone underlying the lower end of the 216-Z-11 Ditch. The scope of this RI included drilling, surface and borehole geophysical surveys, and sampling and analysis of soil. The 200-CW-5 OU RI report (DOE/RL-2003-11) also summarizes previous characterization efforts relating to the 216-U-10 Pond and 216-U-14 Ditch. Characterization activities at the 216-U-10 Pond and 216-U-14 Ditch included drilling, test pit excavation, borehole geophysical surveys, and soil sampling and analysis. With the exception of geophysical logging, no additional soil sampling and analysis were performed at these sites under the 200-CW-5 OU RI because the existing data are considered sufficient for making remedial decisions (BHI-01294, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*) using the analogous site approach discussed in Chapter 2.0 of this FS. The 200-CW-5 OU RI report includes RI results, risk assessment, and modeling for representative sites. The data from the representative sites support the evaluation of remedial alternatives for the OUs in this FS.

1.1 PURPOSE

The purpose of this FS is to develop and evaluate alternatives for remediation of the waste sites in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OUs. This FS refines preliminary potentially applicable or relevant and appropriate requirements, remedial action objectives, and general response actions initially identified in the Implementation Plan (DOE/RL-98-28). Technology screening and alternatives development initially performed in the Implementation Plan are reviewed and refined, as necessary, based on the site-specific data generated in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU RI report (DOE/RL-2003-11) and other sources of existing information. The alternatives considered provide a range of potential response actions (e.g., no action; maintain existing soil cover with monitored natural attenuation and institutional controls; removal, treatment, and disposal; capping; partial removal, treatment, and disposal with capping; in situ vitrification) that are appropriate to address site-specific risk conditions. The alternatives are evaluated against the nine CERCLA evaluation criteria defined in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (Interim Final)*, OSWER 9355.3-01. The Tri-Parties will use this FS as the basis for selecting a remedy to mitigate potential risks to human health and the environment. A preferred remedial alternative (or alternatives) will be presented to the public in DOE/RL-2004-26, *Proposed Plan for the 200-CW-5 (U Pond/Z Ditches), 200-CW-2 (S Pond/Ditches), 200-CW-4 (T Pond/Ditches) Cooling Water Group, and 200-SC-1 Steam Condensate Group Operable Units*), for review and comment.

1.2 SCOPE

Cleanup of the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OUs is a source-control action that addresses contaminated soil and structures (e.g., buried piping) associated with ponds, ditches, trenches, pipelines, concrete retention basins and control structures, UPR sites, and other associated waste sites. Other than the requirement for source-control action to be protective of groundwater and surface water, the scope does not include remediation of groundwater that may be beneath these waste sites. Contaminated groundwater in the 200 East Area is being addressed by the 200-BP-5 OU and 200-PO-1 OU. Contaminated groundwater in the 200 West Area is being addressed by the 200-UP-1 OU and 200-ZP-1 OU.

1.3 REPORT ORGANIZATION

The essential elements of the FS process are presented in Chapters 1.0 through 8.0, and are summarized as follows.

- Chapter 1.0 presents the purpose, scope, and regulatory framework for the FS, as well as this overview of report organization.
- Chapter 2.0 presents descriptions of the physical setting, waste sites, and site contamination; compares analogous sites with the representative sites; and summarizes risk assessments.
- Chapter 3.0 discusses land-use assumptions and develops the overall cleanup objectives and media-specific goals for the waste sites.
- Chapter 4.0 refines the technologies identified for these OUs and waste sites in the Implementation Plan (DOE/RL-98-28) by evaluating new information on existing technologies or promising and relevant emerging technologies. The technologies are broadly screened for applicability to the waste sites in the FS. Screening considerations include effectiveness (likelihood of meeting remedial action objectives for the specific contaminants present at the site), implementability relative to specific site conditions, status of technology development, and relative cost.
- Chapter 5.0 describes the remedial alternative development process, initially conducted as part of the Implementation Plan (DOE/RL-98-28) development, and uses that information in concert with site-specific data from the RI to refine the remedial alternatives to be carried forward for detailed and comparative analyses.
- Chapter 6.0 presents a detailed analysis of each of the remedial alternatives against seven CERCLA evaluation criteria (protection of human health and the environment; regulatory compliance; long-term effectiveness; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost) as defined in EPA/540/G89/004. This chapter also assesses each alternative relative to *National Environmental Policy Act of 1969* values, as required by DOE policy.
- Chapter 7.0 presents the comparative analysis of the six remedial alternatives and identifies their relative advantages and disadvantages, based on the seven CERCLA evaluation criteria. The results of this analysis provide a basis for selecting a remedial alternative for each representative waste site and its analogous waste sites.
- Chapter 8.0 summarizes the conclusions of the FS. This chapter also presents the preferred alternatives and path forward for remediation of the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU waste sites.
- Chapter 9.0 contains all references for the main body of the report; each appendix contains its own reference section.

- Appendix A includes current photographs of the waste sites showing the amount and type of vegetation present on and/or around the waste sites.
- Appendix B presents an analysis of regulatory requirements and available guidance with respect to the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU.
- Appendix C presents the human health and ecological risk evaluations, including the methodology, results, and uncertainties for analogous sites with data.
- Appendix D presents the basis for the comparative cost estimates. Detailed cost estimates are provided for each representative site including applicable alternatives and derived costs for analogous sites.
- Appendix E presents the risk analysis for a potential intruder to the representative sites and analogous sites with characterization data.

1.4 REFERENCES

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," Title 40, *Code of Federal Regulations*, Part 300, as amended.

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National Environmental Policy Act of 1969, 42 USC 4321, et seq.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

Table 1-1. Operable Units and Associated Analogous Sites.

200-CW-5 OU	200-CW-2 OU	200-CW-4 OU	200-SC-1 OU
12 Waste Sites – 3 Unplanned Releases	**8 Waste Sites – 1 Unplanned Release**	**8 Waste Sites**	**13 Waste Sites – 3 Unplanned Releases**
216-U-9 Ditch	216-S-17 Pond	216-T-4A Pond	216-S-5 Crib
216-U-10 Pond	216-S-16P Pond	216-T-4B Pond	216-S-6 Crib
216-U-11 Ditch	207-S Retention Basin	216-T-1 Ditch	216-A-6 Crib
216-U-14 Ditch	216-S-172 Control Structure	216-T-4-1D Ditch	216-A-30 Crib
207-U Retention Basin	2904-S-160 Control Structure	216-T-4-2 Ditch	216-S-25 Crib
216-W-LWC Crib	2904-S-170 Control Structure	207-T Retention Basin	UPR-200-E-19
200-W-84 Process Sewer	216-S-171 Control Structure	200-W-88 Process Sewer	UPR-200-E-21
UPR-200-W-111	216-S-16D Ditch	216-T-12 Trench	UPR-200-E-29
UPR-200-W-112	UPR-200-W-124		200-E-113 Process Sewer
200-W-102 Process Sewer			216-A-37-2 Crib
216-Z-1D Ditch			216-B-55 Crib
216-Z-19 Ditch			216-B-64 Retention Basin
UPR-200-W-110			216-T-36 Crib
216-Z-20 Ditch			200-W-79 Pipeline
216-Z-11 Ditch			207-Z Retention Basin
			207-A North Retention Basin

OU = operable unit.

CHAPTER 2.0 TERMS

bgs	below ground surface
c/min	counts per minute
d/min	disintegrations per minute
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DOE	U.S. Department of Energy
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
FS	feasibility study
FY	fiscal year
HEDL	Hanford Engineering Development Laboratory
MCL	maximum contaminant level
N/A	not applicable
ORP	U.S. Department of Energy, Office of River Protection
OU	operable unit
PFP	Plutonium Finishing Plant
PIF	Plutonium Isolation Facility
PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction Plant
PVC	polyvinyl chloride
RATDU	Radioactive Acid Digestion Test Unit
RBC	risk-based concentration
RECUPLEX	Recovery of Uranium and Plutonium by Extraction Plant
REDOX	Reduction-Oxidation Plant
RESRAD	RESidual RADioactivity (dose model)
RI	remedial investigation
RLS	radionuclide logging system
SLERA	screening-level ecological risk assessment
STOMP	Subsurface Transport Over Multiple Phases (code)
TBP	tributyl phosphate
TEDF	Treated Effluent Disposal Facility
TPH	total petroleum hydrocarbon
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
UPR	unplanned release
URM	Underground Radioactive Material (area)
WIDS	*Waste Information Data System*

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2.0 BACKGROUND INFORMATION

2.1 OPERABLE UNITS BACKGROUND AND HISTORY

This chapter discusses the background and history of waste sites within the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU, including descriptions of the liquid waste-generating processes, the physical setting, natural resources, cultural resources, socioeconomics, representative sites, the nature and extent of contamination at individual waste sites, and a risk evaluation summary.

DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*; BHI-01294, *200-CW-5 U-Pond and Z Ditches Cooling Water Operable Unit Remedial Investigation DQO Summary Report,* and DOE/RL-98-28, *200 Area Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program* (Implementation Plan), identify three representative sites to be characterized for the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU. These representative sites are the 216-U-10 Pond, the 216-U-14 Ditch, and the 216-Z-11 Ditch. The representative sites were selected for evaluation in an RI because of the amount of characterization already performed and because the sites are generally considered worst case (upper bound) or typical of the waste characteristics for the OUs. Two additional representative sites from other OUs (200-TW-1 and 200-CW-1) were selected to support this FS. This was necessary because previously selected representative sites from within 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU were not scheduled for characterization in time to support the FS development schedule. The two additional sites are the 216-A-25 Gable Mountain Pond and the 216-T-26 Crib. Both were selected because they had adequate site characterization to support an FS and because their waste inputs were similar to waste received at their analogous sites. The 216-A-25 Gable Mountain Pond received cooling water and other low-level radioactive effluent from 200 East Area facilities, including the 207-A North Retention Basin. Therefore, it was a logical choice as a representative site for its one analogous site, the 207-A North Retention Basin. The 216-T-26 Crib received waste from the T Plant, as did its analogous sites.

Characterization of the five representative sites was presented in three RIs: DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units* (216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch); DOE/RL-2000-35, *200-CW-1 Operable Unit Remedial Investigation Report* (216-A-25 Pond); and DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)* (216-T-26 Crib). This chapter also summarizes the available information for analogous waste sites (i.e., sites that are not identified as representative sites within the OUs). This information is presented for correlating analogous sites with representative sites. Relationships between analogous and representative sites are developed to support the evaluation of remedial alternatives by application of the analogous site approach described in this chapter and in the Implementation Plan (DOE/RL-98-28).

2.1.1 Buildings and Ancillary Facilities

The Hanford Site, established in 1943, was originally designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. In March 1943, construction began on three reactor facilities (B, D, and F Reactors) in the 100 Areas and three chemical processing facilities (B, T, and U Plants) in the 200 Areas. Operations in the 200 East and West Areas mainly were related to separation of special nuclear materials from spent nuclear fuel (i.e., fuel withdrawn from a nuclear reactor following irradiation). Operations in the 200 Areas took place in eight main processing areas:

- 200 North Area – The 200 North Area was used for temporary storage of irradiated nuclear fuel and contaminated equipment.
- B Plant – In the B Plant, the bismuth phosphate process was used to separate plutonium from irradiated fuel rods. Recovery of cesium, strontium, and rare earth metals also was carried out at B Plant.
- S Plant – In the S Plant, the reduction/oxidation (REDOX) process was used to separate plutonium from irradiated fuel rods.
- T Plant – In the T Plant, the bismuth phosphate process was used to separate plutonium from irradiated fuel rods.
- A Plant – In the Plutonium-Uranium Extraction PUREX Plant, the tributyl phosphate (TBP) process was used to separate plutonium from irradiated fuel rods.
- C Plant – In the Hot Semi Works Plant, pilot plant tests of the REDOX process were conducted before startup of S Plant.
- U Plant – In the U Plant, the TBP process was used to recover uranium from bismuth-phosphate process wastes.
- Z Plant – In the Z Plant, dibutyl butyl phosphate, TBP, carbon tetrachloride, and acids were used in the americium and plutonium separation and recovery process.

The following sections identify the buildings and processes involved in discharging effluent to the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites.

2.1.2 Operable Unit Descriptions

Waste sites in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU received liquid waste streams (principally cooling water and steam condensate) from all of the above-listed processing areas except 200 North Area and C Plant. Several waste sites received sludge removed from retention basins within these OUs. Effluents directed to these sites contained low concentrations of radionuclides and/or chemicals. Additional background information on the history of operations, important waste-generating processes, and liquid waste disposal practices at the various processing areas is provided in Section 3 and Appendix H of the Implementation Plan (DOE/RL-98-28).

The cooling water and steam condensate was designed to be entirely separate from contaminated process liquids. This was accomplished with physical barriers, which typically were the walls of a heating or cooling pipe coil. Steam and cooling water were circulated through coils inside process vessels to adjust the temperatures in the vessels. The spent steam was condensed with cooling water after exiting the process vessel. The condensed steam and cooling water were released to plant sewers or piping systems that discharged to ditches and ponds. The use of very large volumes of cooling water for steam condensation and process vessel cooling resulted in the generation of very large volumes of effluent; more than 90 percent of all liquids discharged to the soil column in the 200 Areas were from cooling water (DOE/RL-98-28).

Over time, coils that circulated steam and cooling water inside chemical process tanks were known to develop pinholes and hairline cracks because of the corrosive chemicals and high thermal gradients in these tanks. These minor defects usually did not lead to contamination of the steam and cooling water because the pressure in the pipe coils was greater than the pressure in the process or condenser vessels; however, on occasions when the pressure in the coils was reduced or suspended, minor leakage through the flaws led to waste stream contamination. Other accidental releases from causes such as operator error also have contributed to contamination of the effluents discharged to the waste facilities in these OUs.

The following sections identify the buildings and processes involved in discharging effluent to the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU waste sites.

2.1.2.1 200-CW-5 U Pond/Z-Ditches Cooling Water Group Operable Unit Description

U Pond

The waste sites in the 200-CW-5 OU primarily received cooling water from the Z Plant and supporting facilities and from the U Plant and its supporting facilities. The 216-U-10 Pond was the final disposal site for most of these waste streams. The pond received 165 billion L (44 billion gal) of water between 1944 and 1985 from a number of facilities by way of the 216-U-14 Ditch and the Z-Ditches. Several ditches and ponds received overflow water from the 216-U-10 Pond and lay outside the fenced portion of 200 West Area.

The 216-U-9 Ditch was excavated in 1952 and extended more than 1000 m (3,279 ft) to the south to the 216-S-17 Pond. This ditch was contaminated in 1953 and later backfilled. The first 500 m (1,640 ft) of the ditch were exhumed, constructing a leg to the 216-S-16 Pond and Ditch system. This system was used sporadically, mostly in the early 1950s and again in the early 1970s. The 216-U-11 Ditch (active between 1944 and 1957) was extended west of the 216-U-10 Pond and received significant quantities of water. The ditch was constructed in a U shape. A pool formed at the center of the U during high overflow conditions.

The waste-generating processes providing effluent to this waste site grouping include the Laundry/Mask Cleaning Facility (2723-W and 2724-W Buildings), which discharged wastewater generated during the cleaning and drying of radiologically contaminated and soiled work clothes. Between 1944 and 1981, laundry effluents were carried by the 200-W-102 Pipeline and discharged to the head end of the 216-U-14 Ditch. The effluents contained lower levels of radionuclides and a variety of detergents and phosphates. Beginning in 1981, laundry waste and mask station waste from the MO-412 Building were directed to the 216-W-LWC Crib.

In addition to the facilities described above, the 282-W Reservoir, the 283-W Water Treatment Plant, and the 284-W Powerhouse actively discharged to the 216-U-14 Ditch through 1984. Wastewater was discharged from the 284-W Powerhouse in three modes: equipment blow-down for scale removal, batch runs for water softener regeneration, and cooling water for routine boiler operations. The water-softening process released a brine solution into the effluent stream. The blow-down process produced an effluent with boiler scale and low levels of residual oxygen-scavenging chemicals such as ethylene diamine tetraacetic acid (EDTA). Other minor waste streams were associated with filter backwashes at the 282 and 283 Facilities. The uppermost 183 m (600 ft) of the 216-U-14 Ditch were converted to the 200-W Powerhouse Pond in 1984 when the ditch was taken out of service; the 200-W Powerhouse Pond remained active until 1995.

Whether wastewater from the laundry, powerhouse, and water treatment system reached the 216-U-10 Pond is unknown. The portion of the 216-U-14 Ditch between the 200-W Powerhouse Pond and the 207-U Retention Basin was backfilled and stabilized after 1984.

The U Plant facilities were a major source of cooling water and steam condensate effluents. The 221-U Chemical Separations (canyon) Building, 222-U Laboratory, and 224-UO_3 Plant constructed between 1943 and 1945, were the third plutonium separations facility at the Hanford Site. The U Plant was planned for use as a training facility. Because training operations did not involve radioactive materials, all waste streams were considered to be uncontaminated. This status changed in 1952 when the plant restarted following conversion for the Uranium Recovery Process (URP). Under this program, uranium was removed from the active single-shell tank farms that had received first-cycle decontamination waste generated in the bismuth phosphate process waste. The plant used a tri-butyl phosphate (TBP) organic separations process, similar to the 202-A PUREX Facility.

Cooling water and steam condensate generated by the URP were collected in waste headers and transported to the two-basin 207-U Retention Basin via pipelines. During operations, effluents sent to one retention basin were sampled and analyzed before being released to the 216-U-14 Ditch.

After 1984, the 216-U-14 Ditch segment between the 207-U Retention Basin and the 216-U-10 Pond was kept open. Low volumes of cooling water and steam condensate were sent to the ditch until 1994 when the section between 207-U and Cooper Avenue was stabilized. The remaining fragment of the 216-U-14 Ditch between Cooper Avenue and the old U Pond was active until 1995, receiving 242-S Evaporator cooling water. This section of the ditch had received operational quantities of 242-S Evaporator cooling water between 1973 and 1980, and again in 1985 for treatment of uranium-bearing groundwater. Additional cooling water was flushed through the 242-S Plant until this ditch segment finally was removed from service in 1995. The 207-U Retention Basin outlet was plugged in 1994 and since then, the basin has been used to collect storm water runoff from the grounds around the 224-UO_3 Plant.

Z-Ditches

The Z-Ditches, consisting of the 216-Z-1D Ditch, 216-Z-11 Ditch, 216-Z-19 Ditch, and 216-Z-20 Crib, are a series of parallel ditches that were used to route cooling and other wastewaters to the 216-U-10 Pond. The 216-Z-1D Ditch was constructed in 1944 to carry cooling water effluents from the 231-Z Plutonium Isolation Plant, the last step in the bismuth phosphate-based plutonium refining process. This facility converted the plutonium into a wet nitrate form. When the bismuth phosphate process at the 221-T Plant shut down in 1956, the 231-Z Plant was converted for use on other projects, addressing metallurgical studies, weapons component fabrications, and reactor fuel development. These processes yielded low-level, low-volume waste.

The startup of the Z Plant in 1949 provided for additional processing steps to convert plutonium nitrate into more stable and safer forms, including oxalate, oxide, and pure metal. Additional process modifications were required to adapt the plant to handle inputs from a larger number of reactors and from new chemical separations (REDOX and PUREX) plants. Machining of plutonium into weapons configurations produced large quantities of scrap. The recovery of uranium and plutonium by extraction (RECUPLEX) process in the Z Plant was used initially for scrap reclamation. Later, adjacent recovery facilities such as the 236-Z Plutonium Reclamation Facility (PRF), the 232-Z incinerator, and the 242-Z Waste Treatment Facility were added. Operations in the Z Plant Complex continued until 1989 and waste discharges to the ground ceased in 1995.

2.1.2.2 200-CW-2 S Ponds and Ditches Cooling Water Group Operable Unit Description

The 200-CW-2 OU includes the cooling water disposal sites used primarily by the REDOX process at the 202-S Canyon Building. Included in the list of disposal sites are the 216-S-16 and 216-S-17 Ponds, the 216-S-16 Ditch, the 207-S Retention Basin, and a series of diversion boxes, weirs, and control structures spread along the pipeline between the 200 West Area fence line and the 216-S-16 Ditch. Also included in this group is one unplanned release (UPR) site, which originated from coil failures inside REDOX process vessels. The failures were responsible for the closing of the 207-S Retention Basin and the 216-S-17 Pond in 1954.

The 216-S-16 Pond and Ditch system was constructed in 1953-1954 near the REDOX Plant by building a dike over a low spot in the topography. Several dike failures in 1958 and 1959 caused a spread of contamination to the north, west, and south of the original pond. In 1965, the 216-S-16 Pond also received contaminated REDOX water from a failed cooling coil at a feed tank, which contaminated much of the ponds and ditches. Between 1973 and 1975, the 216-S-16 Pond and a downstream segment of the 216-S-16 Ditch received overflow from the 216-U-10 Pond by way of the 216-U-9 Ditch.

A number of underground control and diversion (weir) structures, or vaults, were constructed along the pipeline system leading out to the 216-S-16 Ditch. These structures consisted of the 2904-S-170 Sampling Vault (associated with the 2904-SA building) and, in order moving downstream, the 2904-S-160, 216-S-172, and 2904-S-171 Control Structures. The 2904-S-160 Control Structure controlled flow to the 216-S-17 or the 216-S-16 Pond. The 216-S-172 Control Structure appears to have controlled flow to the 216-S-5 Crib.

The 2904-S-171 Control Structure was used to direct flow to the 216-S-16 Pond and Ditch or the 216-S-6 Crib.

Waste sources for the S Ponds and Ditches include the steam condensate and cooling water streams from the 202-S REDOX Chemical Separations Plant. A number of steps in this process were performed at elevated temperatures within caustic environments, so coil failures were more common than at the bismuth phosphate plants. Plant operations were halted in 1967.

2.1.2.3 200-CW-4 T Ponds and Ditches Cooling Water Operable Unit Description

This OU includes waste disposal sites used for the various activities and processes conducted at the 221-T Bismuth Phosphate Plant Complex. The largest volume waste streams at this plant were the combined cooling water and steam condensate streams used during the bismuth phosphate process and the cooling water from the 242-T Evaporator. The waste streams were collected in the 207-T Retention Basin and discharged to the 216-T-4A and 216-T-4B Ponds by way of the 216-T-4-1 and 216-T-4-2 Ditches. More than 42 billion L (11 billion gal) of liquids went to the ground at the 216-T-4A Pond and 216-T-4-1 Ditch between 1944 and 1972, while unknown but much smaller quantities of effluents were discharged to the 216-T-4B Pond and 216-T-4-2 Ditch.

In 1954, the 216-T-12 Trench was excavated near the northeast corner of the 207-T Retention Basin and received slightly contaminated sludge that had accumulated in the basin. This OU also includes the 216-T-1 Ditch, which received a variety of waste from the head-end section of the 221-T Building. The two ponds were located in an area 1600 m (5,250 ft) northwest of the 221-T Building that has since become the 218-W-2A and 218-W-3AE Burial Grounds.

The T Plant Bismuth Phosphate Complex was the first operational chemical separations plant at the Hanford Site. The complex consisted of three major buildings, three tank farms, an evaporator, and a variety of smaller facilities. The bismuth phosphate process was used to process irradiated fuel rods in a batch mode. Production rates were lower than those at the REDOX or PUREX Facility and waste generation also was lower. Leaks in process vessels resulted in significant levels of contamination to the ponds and ditches.

High-activity waste was sent to the T, TX, and TY Tank Farms for storage. With the processing rate exceeding the capacity of existing tank farms, the 242-T Evaporator was constructed to reduce the volume of tank waste. The system operated in batch mode from 1950 to 1955, but was converted to continuous operation in 1965. The facility shut down in 1986.

The bismuth phosphate process ran at 221-T/224-T Plant until 1956, after which the plant was used for a number of minor programs. The plant was used to decontaminate easily moved equipment, relying on acid, caustic, or complexant solutions, detergents, and rinse water to remove the radiological contaminants. Waste solutions were disposed to the T Pond system. The 2706-T Building was constructed in 1964 and used to decontaminate railway equipment and vehicles. Waste from this facility went to a number of waste sites, including the 216-T-4A Pond, between July 1964 and December 1965. Another source of effluents from the 221-T Plant was work performed at the 221-T Facility. In the mid-1940s, this facility was used to conduct scale-up tests on radioactive materials for the bismuth phosphate process. Thereafter, the Pacific Northwest National Laboratory used the facility for a variety of purposes. Waste generated in this part of the building was sent to the 216-T-1 Ditch, which received 178 million L of water between 1944 and 1995.

2.1.2.4 200-SC-1 Steam Condensate Operable Unit Description

A wide variety of processes in the 200 East and 200 West Areas generated steam condensate waste. Volumes varied considerably, a function of the process and its longevity. This operable unit consists of cribs, retention basins, UPRs, and pipelines that received or transported steam condensate from a number of the large processing facilities in the 200 Areas. Large volumes of steam were required to heat or boil process chemistry for effective chemical reactions at REDOX, PUREX, the Uranium Recovery Process at U Plant, and the isotope recovery programs at B Plant.

The 242 Evaporators also released large quantities of steam condensate, only some of which was discharged to these waste sites. The steam was condensed either in use or in off-line condensing units. As in the case of cooling water systems, steam condensate wastewater generally was not contaminated; however, major coil failures and operational errors resulted in significant individual release events. Cribs were the preferred waste disposal sites for steam condensate streams because the failure rate for heating coils was significantly higher than the rate for cooling coils.

Steam condensate from the 221-S REDOX Plant was discharged to the 216-S-16 Pond and Ditch system. Releases that contained minor waste concentrations were diverted to the 216-S-5 Crib. The 216-S-6 Crib received more highly contaminated waste discharges.

A number of process vessels within the PUREX Facility required heating or boiling; therefore, steam condensate was a large-volume waste stream at this plant. Steam condensate from the PUREX Facility was discharged via the 200-E-113 Process Sewer to the 216-A-6, 216-A-30, or 216-A-37-2 Crib. The cribs were located at the southeast corner of the 202-A Canyon Building and were built sequentially as the active cribs began to lose percolation capacity. The 216-A-6 Crib was active between 1955 and 1970, with a break in service between 1961 and 1966 following several incidents of crib flooding caused by the lost percolation or greater-than-design discharge volumes (UPR-200-E-21 and UPR-200-E-29). The 216-A-30 Crib was built as a larger replacement in 1961 and operated until 1966 when rising water levels necessitated bringing the 216-A-6 Crib back on line. It continued in service until 1992. The 216-A-37-2 Crib, one of the largest cribs on site, was constructed in 1983, and received waste until 1995.

In the mid 1960s, the 221-B Plant was converted to recover isotopes from PUREX and REDOX tank waste under the Waste Fractionization Program. A series of ion exchange columns was used to recover cesium and technetium isotopes while a sulfate-based precipitation process was used for strontium, promethium, and rare-earth radionuclides. Solvent extraction technology, based on a variant of the TBP process, also was applied to the recovery of strontium and cesium from selected PUREX waste streams and from other specific waste tanks. The Waste Fractionization Program was designed primarily to remove longer-lived, heat-producing radionuclides from tank waste. The Waste Encapsulation and Storage Facility was constructed at the west end of the 221-B Plant as the 225-B Facility. A diversion capability for above-specification steam condensate was added in 1974 with the installation of the 216-B-64 Retention Basin, a concrete structure with two large rubber bladders, flow gates, and a pump for transferring diverted condensate water to the crib or the 221-B Building. Beyond an initial test with noncontaminated liquid, the structure never was used. The retention basin was isolated in 1996-1997.

2.2 PHYSICAL SETTING

The following sections briefly describe the meteorology, topography, and hydro-geologic frameworks for the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU waste sites. Additional discussions are provided in DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study Report*; PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*; PNNL-13910, *Hanford Site Environmental Report for Calendar Year 2001*; PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*; DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*; DOE/RL-2000-35; DOE/RL-2002-42; and DOE/RL-2003-11.

2.2.1 Meteorology

The Hanford Site lies east of the Cascade Mountains and has a semiarid climate caused by the rain shadow effect of the mountains. Climatological data are monitored at the Hanford Meteorological Station and other locations throughout the Hanford Site. From 1945 through 2001, the recorded maximum temperature was 45 °C (113 °F), and the recorded minimum temperature was –30.6 °C (–23 °F) (PNNL-6415). The two extremes occurred during August and February, respectively. The monthly average temperature ranged from a low of –0.24 °C (31.7 °F) in January to a high of 24.6 °C (76.3 °F) in July. The annual average relative humidity is 54 percent (PNNL-6415).

Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February (PNNL-6415). Normal annual precipitation is 17.7 cm (6.98 in.). Because this area typically receives less than 25.5 cm (10 in.) of precipitation a year, the climate is considered to be semiarid (PNNL-6415).

The prevailing wind direction at the Hanford Monitoring Station is from the northwest during all months of the year (PNNL-6415). Monthly average wind speeds are lowest during the winter months and average about 3 m/s (6 to 7 mi/h). The highest average wind occurs during the summer and is about 4 m/s (8 to 9 mi/h). The record wind gust was 35.7 m/s (80 mi/h) in 1972.

2.2.2 Topography

The Hanford Site is located in the Pasco Basin on the Columbia Plateau. The 200 West Area is located on the 200 Areas Central Plateau near the center of the Hanford Site. The 200 Areas Central Plateau is the common reference used to describe the Cold Creek Bar – a relatively flat, prominent terrace that trends generally east to west with elevations between 198 and 230 m

(650 to 755 ft) above mean sea level. The Cold Creek Bar formed during the cataclysmic flooding events of the Missoula floods, which ended approximately 13,000 years ago.

2.2.3 Geology

The Hanford Site is underlain by basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments. From oldest to youngest, major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Cold Creek unit (formerly, Plio-Pleistocene unit, early "Palouse" soil, caliche layer, or pre-Missoula gravels), and the Hanford formation. A generalized stratigraphic column for the 200 East and 200 West Areas is shown in Figure 2-1. Figure 2-2 shows the locations of the boreholes. Figures 2-3 and 2-4 were generated from boreholes in the 200 West Area near the representative sites to show the spatial relationships of these units across that area.

The Elephant Mountain Basalt Member is bedrock beneath the OUs and consists of a medium- to fine-grained tholeiitic basalt with abundant microphenocrysts of plagioclase (DOE/RW-0164-F, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*). Basalt is overlain by the Ringold Formation over most of the 200 East Area and all of the 200 West Area. The Ringold Formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule to cobble gravel deposited by the ancestral Columbia River. The fluvial-lacustrine Ringold Formation is informally divided into several units; these are (from oldest to youngest) the fluvial gravel and sand of unit A, the buried soil horizons and lake deposits of the lower mud sequence, the fluvial sand and gravel of unit E, and the lacustrine mud of the upper Ringold unit.

The Cold Creek unit overlies the Ringold Formation in the 200 West Area (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*). In the 200 East Area, near the B, BX, and BY Tank Farms, the Cold Creek unit overlies basalt where the Ringold Formation is not present.

In the 200 East Area, the Cold Creek unit previously was interpreted to be the Hanford formation/Plio-Pleistocene (HNF-5507, *Subsurface Conditions Description of the B-BX-BY Waste Management Area*). The Hanford formation/Plio-Pleistocene was interpreted to be equivalent or partially equivalent to the Plio-Pleistocene unit in the 200 West Area or to represent the earliest ice age flood deposits overlain by a locally thick sequence of fine-grained non-flood deposits (HNF-5507).

In DOE/RL-2002-39, the Cold Creek unit is divided into five lithofacies. The five lithofacies units are differentiated based on grain size, sedimentary structure, sorting, fabric, and mineralogy as follows:

- Fine-grained, laminated to massive
- Fine- to coarse-grained, calcium carbonate cemented
- Coarse-grained, multilithic
- Coarse-grained, angular, basaltic
- Coarse-grained, round basaltic lithofacies.

Descriptions of the five lithofacies units, depositional environments, and association with previous site nomenclature are shown in Table 2-1. Detailed descriptions of the lithofacies units are presented in DOE/RL-2002-39.

The Hanford formation overlies the Cold Creek unit in the 200 Areas. Where the Ringold Formation and Cold Creek unit are not present in the 200 East Area, the Hanford formation overlies basalt. The Hanford formation consists of unconsolidated gravel, sand, and silt deposited by cataclysmic floodwaters. These deposits consist of gravel-dominated and sand-dominated facies. The gravel-dominated facies consist of cross-stratified, coarse-grained sands and granule to boulder gravel. The gravel is uncemented and matrix poor. The sand facies consists of well-stratified fine- to coarse-grained sand and granule gravel. Silt content is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common. An upper and lower gravel unit and a middle sand facies are present in the study area.

The cataclysmic floodwaters that deposited sediments of the Hanford formation also locally reshaped the topography of the Pasco Basin. The floodwaters deposited a thick sand and gravel bar that constitutes the higher southern portion of the 200 Areas, informally known as the 200 Area Plateau. In the waning stages of the ice age, these floodwaters also eroded a channel north of the 200 Areas in the area currently occupied by the 216-A-25 Gable Mountain Pond. These floodwaters removed all of the Ringold Formation from this area and deposited Hanford formation sediments directly over basalt.

Holocene-aged deposits overlie the Hanford formation and are dominated by eolian sheets of sand that form a thin veneer across the site, except in localized areas where they are absent. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand. Silty deposits less than 1 m (approximately 3 ft) thick also have been documented at waste sites where fine-grained windblown material has settled out through standing water over many years.

2.2.4 Hydrostratigraphy

A detailed discussion of the hydrostratigraphy in the areas of the representative sites is contained in DOE/RL-2003-11, DOE/RL-2002-42, and DOE/RL-2000-35. This section summarizes this information. The vadose zone is the unsaturated region between the ground surface and water table. In the vicinity of the 200 Areas, the vadose zone thickness ranges from 62 m (206 ft) in the 200 West Area to 105 m (345 ft) in the BC Controlled Area south of the 200 East Area fence.

Details of performance of the aquifer and recharge rates are contained in PNL-10285, *Estimated Recharge Rates at the Hanford Site,* and in PNL-5506, *Hanford Site Water Table Changes 1950 Through 1980 – Data Observation and Evaluation.* Recharge to the unconfined aquifer in the 200 Areas is from artificial and natural sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation at the Hanford Site range from 0 to 10 cm/yr (0 to 4 in/yr) and largely depend on soil texture and the type and density of vegetation. For areas where the ground cover is assumed to remain undisturbed, a recharge rate of 3.5 mm/yr was assumed, which is within the range of values reported for shrub-steppe ground cover. For the disturbed areas above the waste sites (i.e., stabilization cover), a recharge rate of 1.44 cm/yr has been assumed. Artificial recharge occurred when effluents such as cooling water and process waste water were disposed to the ground. PNL-5506 reports that between 1943 and 1980, 6.33 x 10^{11} L (1.67 x 10^{11} gal) of liquid wastes were discharged to the soil column. Most sources of artificial recharge have been halted. The artificial recharge that does continue is largely limited to liquid discharges from sanitary sewer system drain fields, two state-approved land disposal structures, and 140 small-volume uncontaminated miscellaneous streams. A state-approved land disposal site is located 366 m (1,200 ft) north of the 200 West Area exclusion fence and receives liquid waste that has been treated at the 200 Areas Effluent Treatment Facility in the 200 East Area (*Waste Information Data System* (WIDS), 600-211, *General Summary Report*). While the liquid waste disposal facilities were operating, many localized areas of saturation or near saturation were created in the soil column. With the reduction of artificial recharge in the 200 Areas, these locally saturated soil columns are dewatering. As the soil column dewaters, the moisture flux decreases. Residual moisture in the vadose zone, however, may remain for some time. In the absence of artificial recharge, the potential for recharge from precipitation becomes a primary driving force for contaminant movement in the vadose zone.

The unconfined aquifer in the 200 Areas occurs in the Hanford formation, the Cold Creek unit, and the Ringold Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where it is lower (the Columbia River) (PNNL-13788). In general, groundwater flow through the 200 Areas Central Plateau occurs in a predominantly easterly direction, from the 200 West Area to the 200 East Area (Figure 2-5).

Historical discharges to the ground greatly altered the groundwater flow regime, especially around 216-U-10 (U Pond) in the 200 West Area and 216-B-3 (B Pond) in the 200 East Area. Discharges to the 216-U-10 Pond resulted in a groundwater mound developing in excess of 26 m (85 ft). Discharges to the 216-B-3 Pond created a hydraulic barrier to groundwater flow coming from the 200 West Area, deflecting it to the north through the gap between Gable Mountain and Gable Butte, or to the south of the 216-B-3 Pond. As the hydraulic effects of these two artificial recharge sites diminish, groundwater flow is expected to acquire a more easterly course through the 200 Areas, with some flow possibly continuing through Gable Gap (BHI-00469, *Hanford Sitewide Groundwater Remediation Strategy – Groundwater Contaminant Predictions*).

2.3 NATURAL RESOURCES

Natural resources in the study area and vicinity include vegetation and wildlife resources. Biological and ecological information aids in evaluating impacts to the environment from contaminants in the soils, including potential effects of implementing remedial actions and identification of sensitive habitats and species. This section also considers cultural and aesthetic resources and socioeconomics associated with activities in the 200 Areas.

Survey data collected in 2000 and 2001 for the 200 Areas Central Plateau as part of the Ecological Compliance Assessment Project were compiled to support Central Plateau ecological evaluations (DOE/RL-2001-54, *Central Plateau Ecological Evaluation*). The information includes plant community descriptions, identification of plant and wildlife species, and avian census data. Designated levels of habitat under DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*, including rare plant populations, are identified and mapped. The data were collected before the Command 24 fire occurred in 2000. The fire, however, did not impact any of the waste sites being considered in this FS.

2.3.1 Vegetation

Vegetation in the study area is characterized by native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the dominant shrub is big sagebrush (*Artemisia tridentata*). The understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*), and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus spp.*), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that also are present include Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), milkvetch (*Astragalus spp.*), yarrow (*Achillea millefolium*), dwarf evening primrose (*Camissonia pygmaea*), and daisy (*Erigeron spp.*). Dwarf evening primrose is a rare plant and has not been encountered in the study area.

Many of the waste disposal and storage sites in the 200 Areas have been backfilled with clean soil and planted with crested or Siberian wheatgrass (*Agropyron cristatum* and *Agropyron sibericum*, respectively) to stabilize surface soil, control soil moisture, or displace more invasive deep-rooted species like Russian thistle (PNNL-6415). The area associated with the waste sites addressed in this FS is highly disturbed. This disturbed habitat primarily is the result of mechanical and operational disturbance. Outlying habitats also have been disturbed as a result of range fires, clearing, and construction activities.

2.3.2 Wildlife

The largest mammal frequenting the study area is the mule deer (*Odocoileus hemionus*). Mule deer are much more common along the Columbia River; the few that forage throughout the 200 Areas make up a distinct group called the Central Population (PNNL-11472, *Hanford Site Environmental Report for Calendar Year 1996*). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve. Elk, which are more dependent on open grasslands for forage, seek the cover of sagebrush and other shrub species during the summer months. The Rattlesnake Hills herd of elk that inhabits the Hanford Site primarily occupies the Arid Lands Ecology Reserve and private lands that adjoin the reserve to the south and west. They occasionally are seen in the 200 Areas and just south of them and have been sighted at the White Bluffs boat launch on the Hanford Site. The herd tends to congregate on the Arid Lands Ecology Reserve in the winter and disperses during the summer months to higher elevations on the Arid Lands Ecology Reserve, private land to the west of the Arid Lands Ecology Reserve, and the Yakima Training Center. In March 2000, about 200 elk were removed from the Arid Lands Ecology Reserve and relocated, and another 31 elk were removed during 2002. Special hunts adjacent to the Hanford Site in 2000 accounted for the removal of 207 additional elk. The "24 Command Fire" in June 2000 temporarily destroyed nearly all of the elk forage on the Arid Lands Ecology Reserve. The herd moved onto unburned private land west of the Site, to unburned areas in the center of the Hanford Site, and along the Columbia

River near the 100 B/C and 100 K Areas. Elk have returned to burned areas as the vegetation recovers (PNNL-6415).

Experienced biologists reported sighting a cougar (*Felis concolor*) on the Arid Lands Ecology Reserve during the elk relocation in March 2000, supplementing anecdotal accounts of other observations of the presence of a cougar on the Hanford Site (PNNL-6415).

Other mammals common to the 200 Areas are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 200 Areas radioactive waste sites (BNWL-1794, *Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, 200 East Area*). The majority of badger diggings are a result of searches for food, especially for other burrowing mammals such as pocket gophers and mice. Pocket gophers, Great Basin pocket mice, and deer mice are abundant herbivores in the 200 Areas. These small mammals can excavate significant amounts of soil as they construct their burrows (e.g., Hakonson et al. 1982, "Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers"). Mammals associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the study area include the starling (*Sturnus vulgaris*), horned lark (*Eremophila alpestris*), meadowlark (*Sturnella neglecta*), western kingbird (*Tyrannus verticalis*), rock dove (*Columba livia*), black-billed magpie (*Pica pica*), and raven (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the 200 Areas in abandoned badger or coyote holes, or in open-ended stormwater pipes along roadsides in more industrialized areas. Loggerhead shrike (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive waste sites.

Reptiles common to the study area include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Rattlesnakes (*Crotalus viridis*) also have been observed. Reptile sightings are not widespread, with only 23 observations of side-blotched lizards at 316 sites surveyed during a 2001 Ecological Compliance Assessment Project survey (Appendix B of DOE/RL-2001-54).

Three of the most common groups of insects include darkling beetles, grasshoppers, and ants. Ants have been known to burrow up to 2.7 m (9 ft) into the vadose zone and to bring contaminants to the surface.

2.3.3 Species of Concern

The Hanford Site is home to a number of species of concern, but many of these are associated with the Columbia River and its shoreline. Two Federally protected species have been observed at the Hanford Site, the Aleutian Canada goose (*Branta canadensis leucopareia*) and the bald eagle (*Haliaeetus leucocephalus*). Both depend on the river corridor and rarely are seen in the Central Plateau. As migratory birds, these species also are protected under the *Migratory Bird Treaty Act of 1918*.

Several threatened, endangered, and candidate species are found in and near the 200 Areas. These species include the ferruginous hawk (*Buteo regalis*), burrowing owl, loggerhead shrike, long-billed curlew, and sage sparrow. Plant species of concern (which include those listed as state endangered, threatened, sensitive, and monitored) that may occur in the study area include dwarf evening primrose and Piper's daisy (*Erigeron piperianus*) (WNHP 1998, *Washington Rare Plant Species by County*).

Plant and animal species of concern, their designations, and the places of their occurrence can change over time. At this time, it is not anticipated that remediation of the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OUs will affect any species of concern, but incorporating the needs of these species into project planning will help to mitigate any potential effects. Especially important is avoiding, where possible, undisturbed shrub-steppe habitat because this is important to many species of concern. The undisturbed shrub-steppe in the Central Plateau was designated as Level 3 habitat in DOE/RL-96-32, which requires mitigation of any disturbance (for example through avoidance and minimization) and possibly rectification and compensation. More detailed direction on protecting Level 3 habitats and species of concern is provided in DOE/RL-96-32. In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure that ecological resources are adequately protected.

2.3.4 Cultural Resources

A comprehensive archaeological survey of the 200 Areas found artifacts in conjunction with areas of high topographic relief and in the vicinity of sources of permanent water, but few artifacts associated with open, inland flats (PNL-7264, *Archaeological Survey of the 200 East and 200 West Areas, Hanford Site, Washington*). In the 200 West Area, the only culturally sensitive area identified is the historic White Bluffs Road that crosses the northwest corner of the site. The report concluded that additional cultural resource reviews are required only for proposed projects within 100 m (328 ft) of this road. None of the waste sites associated with the OUs involved in this FS are within 100 m (328 ft) of this road (PNL-7264).

PNL-7264 addressed only undisturbed portions of the 200 Areas and did not address facilities and structures. The *National Historic Preservation Act of 1966* requires agencies to consult with the State Historic Preservation Officer and the Advisory Council on Historic Preservation to ensure that all potentially significant cultural resources, including structures and associated sites, have been adequately identified, evaluated, and considered in planning for a proposed undertaking (e.g., remediation, renovation, or demolition) (DOE/RL-97-56, *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan*).

DOE/RL-97-56 was developed to address these requirements and to determine the eligibility of historic properties for the "National Register of Historic Places" (36 CFR 60). DOE/RL-97-56 evaluated and classified waste sites and structures on the Hanford Site, including those in the 200 Areas, and proposed recommendations for mitigation. Treatment options for mitigation were determined using 36 CFR 60, Section 60.4, "Criteria for Evaluation." None of the waste sites in the OUs that are subjects of this FS were recommended for individual documentation as contributing properties. Sites beginning with "216" (e.g., 216-U-10 Pond, 216-U-14 Ditch) were categorized as "noncontributing/exempt properties" (i.e., properties that are exempted from documentation requirements as potential historic sites) (DOE/RL-97-56). Some sites not addressed in DOE/RL-97-56, such as UPRs and septic tanks that were not considered to be significant enough to be evaluated as part of that effort, will be evaluated under site-specific pre-remediation cultural resource reviews.

No cultural resources have been directly associated with OU waste sites (PNL-7264, DOE/RL-97-56, PNNL-6415); however, site-specific cultural resource reviews will be required for each waste site before remediation or other ground-disturbing activities are begun. In addition to the site-specific review, a cursory field review of plant and animal life may be conducted in concert with this effort.

2.3.5 Aesthetics, Visual Resources, and Noise

With the exception of Rattlesnake Mountain, land on the Hanford Site generally is flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,478 ft) above mean sea level, forms the southwestern boundary of the Hanford Site, and Gable Mountain and Gable Butte are the highest landforms on the Hanford Site itself. The view toward Rattlesnake Mountain is visually pleasing, especially in the springtime when wildflowers are in bloom. Large rolling hills are located to the west and far north. The Columbia River, flowing across the northern part of the Site and forming the eastern boundary, generally is considered scenic.

Studies at the Hanford Site on the propagation of noise have been concerned primarily with occupational noise at work sites. Environmental noise levels have not been extensively evaluated because of the remoteness of most Hanford Site activities and their isolation from receptors covered by Federal or state statutes. Most industrial facilities on the Hanford Site are located far enough away from the Site boundary that noise levels at the boundary are not measurable or are indistinguishable from background noise levels (PNNL-6415).

2.3.6 Socioeconomics

Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities and other parts of Benton and Franklin counties. The agricultural community also has a significant effect on the local economy. Any major changes in Hanford Site activity would potentially affect the Tri-Cities and other areas of Benton and Franklin Counties. Unless otherwise specifically cited, data in this section are collected from interviews with the referenced organization.

The Hanford Site is the largest single source of employment in the Tri-Cities. During fiscal year (FY) 2002, an average of 10,892 employees were employed by the U.S. Department of Energy (DOE) Office of River Protection (ORP) and its prime contractor CH2M HILL Hanford Group, Inc.; DOE-Richland Operations Office and its prime contractor Fluor Hanford, Inc.; Battelle Memorial Institute; Bechtel Hanford, Inc.; and the Hanford Environmental Health Foundation. The FY 2002 year-end employment at the Hanford Site was 10,938, up from 10,670 in FY 2001. In addition to these totals, Bechtel National, Inc., and its prime subcontractor Washington Group International employed 3,013 at the end of FY 2002, up from 1,350 at the end of FY 2001. In

December 2000, ORP awarded a contract to Bechtel National, Inc., to design, build, and start up waste treatment facilities for the glassification of liquid radioactive waste. According to the Washington State Labor Market and Economic Analysis, the annual average number of employees at the Hanford Site is down considerably from a peak of 19,200 in FY 1994, but still represents 15 percent of the 94,000 total jobs in the economy.

In addition to the Hanford Site, other key employers in the area are as follows:

- Energy Northwest
- The agricultural community (including the Lamb Weston food processing plants)
- Iowa Beef Processing
- Framatome – Advanced Nuclear Products (formerly Siemens, Inc.)
- Boise Cascade Corporation, Paper and Corrugated Container Divisions
- Burlington Northern and Santa Fe Railroads.

Tourism and government transfer payments to retirees in the form of pension benefits also are important contributors to the local economy.

An estimated total of 147,600 people lived in Benton County and 51,300 lived in Franklin County during 2002, for a total of 198,900, which is up almost 4 percent from 2000. According to the 2000 Census, population totals for Benton and Franklin Counties were 142,475 and 49,347, respectively. Both Benton and Franklin counties grew at a faster pace than Washington as a whole in the 1990s. The population of Benton County grew 26.6 percent, up from 112,560 in 1990. The population of Franklin County grew 31.7 percent, up from 37,473 in 1990 (Census 2001a).

Based on the 2000 census, the 80 km (50-mi) radius area surrounding the Hanford Site had a total population of 482,300 and a minority population of 178,500.[1] The ethnic composition of the minority population is primarily White Hispanic (24 percent), self-designated "other and multiple" races (63 percent), and Native American (6 percent). Asians and Pacific Islanders (4 percent) and African American (3 percent) make up the rest. The Hispanic population resides predominantly in Franklin, Yakima, Grant, and Adams counties. Native Americans within the 80 km (50-mi) area reside primarily on the Yakama Reservation and upstream of the Hanford Site near the town of Beverly, Washington. PNNL-6415 provides maps showing distributions of minority and low-income populations.

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[1]PNNL-6415 shows the total population "within" 80 km as 511,500, which was estimated by a geographical information system from the populations of individual census block groups, the smallest geographic area for which both minority and poverty status were estimated in the 2000 Census. The higher number resulted because the total population of a census block group previously was assigned to the 80 km area if *any part* of the block group lay within 80 km of the Hanford Meteorological Station in the middle of the Hanford Site. The new estimate splits boundary block groups to include only those portions within 80 km, which should result in a lower and more accurate estimate.

2.4 WASTE SITE DESCRIPTIONS

This section describes the five selected representative sites for the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU. Detailed descriptions of these representative sites are provided to support development of contaminant distribution models, to evaluate risk, and to provide a baseline for implementing the analogous site approach in support of the RI/FS process. Data for these sites are presented in DOE/RL-2003-11; DOE/RL-2003-64, *Feasibility Study for the 200-TW-1 Scavenged Waste Group, the 200-TW-2 Tank Waste Group, and the 200-PW-5 Fission-Product-Rich Waste Group Operable Units*; DOE/RL-2002-69, *Feasibility Study for the 200-CW-1 and 200-CW-3 Operable Units and the 200 North Area Waste Sites*; the Implementation Plan (DOE/RL-98-28); and DOE/RL-99-66.

Three of the representative sites (216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch) are from the 200-CW-5 OU. Two representative sites (216-A-25 Gable Mountain Pond and 216-T-26 Crib) are from the 200-CW-1 and 200-TW-1 OUs, respectively. These two sites were selected because they had adequate site characterization to support an FS and because their waste inputs were similar to waste received at their analogous sites. The 216-A-25 Gable Mountain Pond received cooling water and other low-level radioactive effluent from 200 East Area facilities, including the 207-A North Retention Basin. Therefore, it was a logical choice as a representative site for its one analogous site, the 207-A North Retention Basin. The 216-T-26 Crib received waste from the T Plant, as did its analogous sites.

2.4.1 Representative Sites

2.4.1.1 216-U-10 Pond

The 216-U-10 Pond was constructed in 1943-1944 in a natural topographic depression to act as a seepage area for infiltration of wastewater from the 216-U-14 and 216-Z Area Ditches. The pond is located in the southwestern corner of the 200 West Area. The pond later was diked on the south and west edges, and three overflow trenches were added on the east side in approximately 1952-53 to increase the pond's capacity. At its maximum extent, including the overflow trenches, the pond covered an area of roughly 12 ha (30 a). The location of the 216-U-10 Pond is shown in Figure 1-2.

In 1985, the pond was deactivated and interim stabilized. Stabilization activities included scraping contaminated pond sediments from peripheral areas to a depth of 0.3 m (1 ft) or more and placing the sediments in the center of the pond. The peripheral areas were covered with a minimum of 0.6 m (2 ft) of clean soil, and the central pond area was covered with a minimum of 1.2 m (4 ft) of clean soil and seeded (DOE/RL-95-106, *Focused Feasibility Study for the 200-UP-2 Operable Unit*). In 1990, 0.6 ha (1.5 a) of contaminated soil on the south side of the pond was covered with an additional 0.6 m (2 ft) of clean fill to stabilize surface contamination (DOE/RL-91-58, *Z Plant Source Aggregate Area Management Study Report*). In November 1994, contamination was detected along the south and west perimeters of the pond (about 1 ha [2.5 a]) and was stabilized with soil from the 216-U-11 Borrow Pit.

The 216-U-10 Pond received an estimated 1.65 x 10^{11} L (4.3 x 10^{10} gal) of low-level liquid waste (DOE/RL-91-58 and DOE/RL-96-81). The total inventory of radionuclides discharged to the pond system is estimated to include plutonium, uranium, Am-241, Cs-137, and Sr-90 (DOE/RL-96-81). The discharge volume and inventory of the 216-U-14 Ditch and Z-Ditches are included in these totals.

2.4.1.2 216-U-14-Ditch

The 216-U-14 Ditch began operating in 1944 to channel effluent to the 216-U-10 Pond. The ditch was an unlined, open excavation approximately 1.2 m (4 ft) wide at the bottom (with a 2.5:1 side slope), 3.1 m (10 ft) deep, and 1731 m (5,680 ft) long. It originated about 500 m (1,600 ft) northwest of U Plant at the 284-WB Powerhouse Pond and terminated at the 216-U-10 Pond (Figure 1-2). The ditch and the 216-U-10 Pond provided a disposal capability for low-level radioactive wastewater by infiltration and evaporation.

The contaminant inventory and volume of effluent discharged to the ditch are included with the 216-U-10 Pond inventory.

To prevent backups and accumulation of standing wastewater, the ditch was dredged periodically. Sediments removed during dredging activities were piled on a berm located on the west bank of the ditch. These sediments were removed and buried in a low-level burial ground in 1979 to reduce the spread of contamination (WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*).

In 1985, the 216-U-10 Pond and a portion of the 216-U-14 Ditch were stabilized with sand and gravel to control surface contamination. After stabilization in 1985, approximately 430 m (1,410 ft) of the ditch length remained active for percolation of effluent. In 1986, an accidental release led to the discharge of approximately 2365 L (625 gal) of reprocessed nitric acid to the ditch in less than 1 day. This release occurred during transfer of the acid from a storage tank. The release was diluted with cooling water originating from the 224-UO_3 Plant. The residual effluent stream had a pH of less than 2.0 and contained approximately 39 kg (86 lb) of uranium (Whiting 1988, "Unusual Occurrence Report, Public Information Release").

In 1992, the lower open end of the ditch (westernmost end of the ditch) was partially stabilized with an engineered barrier to control surface contamination. The slopes were pushed in, approximately half of the ditch was brought to grade, and the ditch was backfilled with large boulders and gravel. The remaining open section of the ditch received effluent until April 1995, when it was stabilized by chemically killing all vegetation, consolidating the contaminated soil into the center of the ditch, and backfilling with clean soil.

2.4.1.3 216-Z-11 Ditch

The 216-Z-11 Ditch was the second of three ditches constructed to transfer wastewater from the Z Plant facilities to the 216-U-10 Pond. Beginning in December 1944, the first "Z-Ditch," currently designated the 216-Z-1D Ditch, received effluent from the 231-Z Building. The 216-Z-1D Ditch was constructed as an unlined, open excavation 1295 m (4,249 ft) long and 0.6 m (2 ft) deep, with a bottom width of 1.2 m (4 ft), side slopes of 2.5:1, and a minimum grade of 0.05 percent (WHC-EP-0707). The original headwall of the 216-Z-1D Ditch was located approximately 60 m (196 ft) east of the 231-Z Building.

In July 1949, as part of Z Plant construction, a vitreous clay pipeline 45.7 cm (18 in.) in diameter was installed to replace the upper portion of the 216-Z-1D Ditch, and a new headwall was constructed approximately 457 m (1,500 ft) downstream. The abandoned upper portion of the ditch was backfilled.

In March 1959, after high levels of plutonium contamination were discovered in the 216-Z-1D Ditch, construction began on the 216-Z-11 Ditch as a replacement. The 216-Z-11 Ditch was excavated just east of and parallel to the 216-Z-1D Ditch and was of similar design and construction. Material removed during excavation was used to backfill the 216-Z-1D Ditch to existing grade. The 216-Z-11 Ditch merged back into the original 216-Z-1D Ditch at the lower end between the 216-U-10 Pond delta region and 16th Street crossing. The entire ditch was redesignated as the 216-Z-11 Ditch. In this configuration, the ditch was approximately 797 m (2,615 ft) long, with the upper 36.5 m and lower 202.6 m (120 ft and 665 ft, respectively) in common with the original 216-Z-1D Ditch.

In April 1971, the 216-Z-11 Ditch was retired and replaced with a third ditch, 216-Z-19. The 216-Z-19 Ditch was constructed west of and parallel to the 216-Z-1D and 216-Z-11 Ditches. During construction of the 216-Z-19 Ditch, contaminated sediments from the upper portion of the 216-Z-1D Ditch were inadvertently excavated over an estimated length of 130 m (427 ft). This soil was buried in a trench that was excavated parallel to and east of the 216-Z-11 Ditch. The 216-Z-19 Ditch subsequently was shifted farther west of the original 216-Z-1D Ditch. A temporary alignment resulted in the 216-Z-19 Ditch reentering the existing 216-Z-11 Ditch to use the culvert beneath 16th Street. In October 1971, a new culvert was installed 15 m (49 ft) to the west, and the 216-Z-19 Ditch was realigned and continued approximately 305 m (1,000 ft) to the 216-U-10 Pond. Material excavated during the installation of the 216-Z-19 Ditch was used to backfill the 216-Z-11 Ditch to grade.

In late March 1976, an accidental release of contamination occurred in the 216-Z-19 Ditch, and efforts were made to contain the contaminants in the ditch. A series of three dams was constructed at intervals along the upper portion of the ditch. A water sprinkler system was installed between the lowermost dam and the 216-U-10 Pond to prevent this portion of the ditch from drying out. In March 1978, the sprinklers were shut down and the dams were removed, but the remaining surface water infiltrated before reaching the pond. Wastewater was diverted from the 216-Z-19 Ditch to the 216-Z-20 Crib shortly afterward.

Deactivation and stabilization of the Z-Ditches began in 1981, following construction of the 216-Z-20 Crib as the primary Z Plant wastewater disposal facility. Woody vegetation in the 216-Z-19 Ditch was killed with herbicides (glyphosate and dicamba) before backfill operations were initiated. The 216-Z-19 Ditch was covered with 0.6 to 0.9 m (2 to 3 ft) of clean soil. The concrete headwalls, vegetation, and miscellaneous unsalvageable equipment were incorporated into the ditch bottom. At the same time, the previously buried 216-Z-1D and 216-Z-11 Ditches received an additional 0.15 to 0.30 m (0.5 to 1.0 ft) of clean fill. The entire Z-Ditch Complex was reposted as an Underground Radioactive Area.

Information in DOE/RL-96-81 indicates that the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches received an estimated 140 g, 8.07 kg, and 140 g of plutonium, respectively, during their periods of active use. These estimates are based on limited waste-stream discharge sampling collected during more than 35 years of continuous operation. No discharge records exist for the period of 1961 through 1966. During this time, the Space Nuclear Auxiliary Power program was operating in Z Plant and producing purified Np-237 and Pu-238. A cumulative plutonium release quantity of 7.86 kg was reported for the period 1959 through 1967, representing 96 percent of the total estimated inventory for the 216-Z-11 Ditch (WHC-EP-0707).

Significant uncertainty exists in estimates of plutonium inventory based on waste stream chemistry. Waste effluent sampling likely was performed by alpha count and then converted to plutonium concentrations. This method can significantly overestimate the quantity of plutonium. Conversely, periodic waste stream sampling likely would not reflect intermittent, short-term higher concentration discharge incidents and, thus, would underestimate the total plutonium released to the ditches.

Soil samples collected in 1959 from the 216-Z-1D Ditch indicated very high plutonium levels in the ditch. Based on the 1959 sampling data, the results of their Z-Ditch characterization, and information obtained when the head end of the 216-Z-1D Ditch mistakenly was unearthed during excavation of the 216-Z-19 Ditch, WHC-EP-0707 concluded that the historical plant operations inventory estimates for the Z-Ditches were erroneous. The conclusion in WHC-EP-0707 was that the 216-Z-1D Ditch likely contains from 3 to 10 kg of plutonium, with both the 216-Z-11 and 216-Z-19 Ditch inventories an order of magnitude lower.

2.4.1.4 216-A-25 Gable Mountain Pond

The 216-A-25 Pond, at 29 ha (71 a) is the largest seepage disposal facility of the Hanford Site pond network, located 1 mi south of the west end of Gable Mountain. It was commissioned for service in 1957 to receive cooling water from PUREX Plant operations. The 216-A-25 Gable Mountain Pond routinely has received low-level liquid effluents since its inception and received wastewater from B Plant, the 242-A Evaporator/Crystallizer, the 244-AR Vault, the East Area powerhouse, and the A Tank Farm. Between its commissioning in 1957 and decommissioning in 1987, the pond received 307,000,000,000 L (81,200,000,000 gal) of liquid mixed waste. Radionuclides present in the waste streams received include Am-241, H-3, Ru-106, Cs-137, Pm-147, Sr-90, and plutonium.

Although the pond has received low levels of radioactivity and chemically contaminated liquid effluents, a single UPR in 1964 resulted in discharge of relatively large quantities of short- and long-lived fission products. Bentonite clay intentionally was introduced to the pond bottom in an attempt to retain radioactivity in the upper sediment layers. Copper sulfate, to a concentration of 3 p/m, was added on two occasions to eliminate algae and invertebrate life, thus breaking important links in the food chain of migratory waterfowl.

More than 90 percent of the contamination at the 216-A-25 Gable Mountain Pond has been found to reside within the upper 5 cm (2 in.) of sediment; however, monitoring wells located near the northern shoreline have produced sample results that indicate Sr-90 is in the groundwater.

Cleanup actions started in 1984. The stabilization was completed in 1988. The pond was backfilled with clean pit run soil and cobble to a minimum of 0.6 m (2 ft) above the original shoreline. In 1991, there was evidence of another pond that had developed over the old one. The site revegetated after an additional 1 ft of topsoil was spread over the entire backfilled area.

2.4.1.5 216-T-26 Crib

The 216-T-26 Crib is an inactive liquid waste disposal site located 61 m (200 ft) north of 22nd Street and east of the TY Tank Farm (WHC-MR-0227, *Tank Wastes Discharged Directly to the Soil at the Hanford Site*). The 216-T-26 Crib is fenced within a light chain barricade and underground contamination warning placards.

Between August 1955 and November 1956, the 216-T-26 Crib received approximately 1.2×10^7 L (3.2×10^6 gal) of liquid waste. This waste originated at T Plant as metal waste and first-cycle waste that had been recovered through the URP and scavenged at U Plant. The waste then was transferred back to the TY Tank Farm to allow the sludge to settle; the liquid effluent was discharged to the 216-T-26 Crib (WHC-SD-EN-TI-014, *Hydrogeologic Model of the 200 West Groundwater Aggregate Area;* PNL-6456, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*).

Crib construction is described as follows. A 36 cm (14-in.) steel inlet pipe reduces to a 25 cm (10-in.) pipe located approximately 3 m (9 ft) below grade. The smaller section of pipe branches into four 20 cm (8-in.) steel pipes that feed the large-diameter vertical concrete pipes, which are approximately 1.2 m (4 ft) long and 1.2 m (4 ft) in diameter. The piping lies within a 9 by 9 by 4.6 m (30 by 30 by 15 ft) deep excavation. The base of the crib was placed at 4.6 m (15 ft) below ground surface (bgs), and the excavation was filled with approximately 2.4 m (8 ft) of gravel followed by approximately 2.4 m (8 ft) of earth backfill.

The crib was deactivated in 1956 by blanking the line leading to the 216-T-26 and 216-T-28 Cribs between the TY Tank Farm and the roadway. In 1975, stabilization activities were performed, which consisted of scraping off the top 15 cm (6 in.) of soil and replacing the excavated material with clean fill to the original grade (WHC-MR-0227). The contaminated soil was placed in the 200 West Area dry waste burial grounds. The crib was surface stabilized again in May 1990 (WIDS).

Waste disposed of at this unit includes ferrocyanide complexes, fluoride, nitrate, nitrite, phosphate, sodium, sodium aluminate, sodium hydroxide, sodium silicate, sulfate, Cs-137, Ru-106, Sr-90, plutonium, and uranium.

2.4.2 Summary of Data Collection Activities

This section summarizes the data collection activities performed during the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OU RI, as well as data collection activities performed at the two representative sites from the 200-CW-1 OU and 200-TW-1 OU. This section also covers drilling, sampling, analysis, and geophysical logging. The following section, "Nature and Extent of Contamination," discusses the analytical results.

The RI for the 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 OUs was conducted in accordance with DOE/RL-99-66 and DOE/RL-2002-24 *(200-CW-5 U Pond/Z Ditches Cooling*

Water Group Operable Unit Remedial Investigation Sampling and Analysis Plan). The 200-CW-2, 200-CW-4 cooling water, and 200-SC-1 steam condensate OUs are consolidated with the 200-CW-5 OU because they received similar waste streams (i.e., cooling water, steam condensate, or both) and because the contaminant distribution beneath these waste sites is expected to be similar.

The 200-CW-5 RI focused on characterization of three representative waste sites in the 200-CW-5 OU: 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch. These three representative waste sites originally were identified in DOE/RL-96-81 and the Implementation Plan (DOE/RL-98-28). In evaluating the representative sites, the data quality objective process was applied to determine the data that should be collected to assess site conditions and support remedial decision making. The 200-CW-5 OU representative waste sites were selected for characterization because waste stream inventories, effluent volumes received, and the current level of characterization all suggested that high contaminant inventories are present in the subsurface beneath these receiving sites.

The RI was conducted from January to October 2002. Efforts consisted largely of drilling a single borehole (C3808) and performing soil sampling and analysis, geophysical logging, and a pipeline investigation at the 216-Z-11 Ditch representative site. In addition, boreholes 299-W18-15 and 299-W23-16 were geophysically logged at the 216-U-10 Pond and 216-U-14 Ditch, respectively. These efforts are summarized in CP-12134, *Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5 U-Pond/Z-Ditches Cooling Water Operable Unit*.

Most of the data from the 216-U-10 Pond and 216-U-14 Ditch were collected as part of the 200-UP-2 limited field investigation and other activities previously conducted at the Hanford Site. No additional data collection activities were conducted at these sites during the RI, with the exception of geophysical logging. Additional data were not collected because BHI-01294 concludes that data collected before the RI was performed were sufficient to make remedial decisions. Locations of characterization boreholes, test pits and other sample locations are shown in Figure 2-2.

This FS also uses two representative sites not contained in the RI for the 200-CW-5, 200-CW-2, 200-CW-4 and 200-SC-1 OUs: the 216-A-25 Gable Mountain Pond and the 216-T-26 Crib.

Similar site characterization information for the 216-A-25 Gable Mountain Pond is contained in the RI for the 200-CW-1 OU (DOE/RL-2000-35) and the corresponding FS (DOE/RL-2002-69).

Site investigation data for the 216-T-26 Crib is contained in the RI for the 200-TW-1, 200-TW-2, and 200-PW-5 OUs (DOE/RL-2002-42). A summary of data collection activities, as well as drilling, sampling, analysis, and geophysical logging descriptions, is contained in the corresponding FS (DOE/RL-2003-64).

2.4.2.1 216-U-10 Pond Characterization

The limited field investigation at the 216-U-10 Pond was performed between August 1993 and August 1994. Limited field investigation activities at the 216-U-10 Pond were conducted to determine the nature and vertical extent of the contamination beneath the pond. The results are published in DOE/RL-95-13, *Limited Field Investigation for the 200-UP-2 Operable Unit*; BHI-00034, *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area*; and BHI-00033, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit*. Limited field investigation activities consisted of a surface radiation survey, soil and vegetation sampling and analysis, the installation of 10 cone penetrometer pushes, one borehole, a test pit excavation, and geophysical logging. Soil samples were collected and analyzed for chemicals (i.e., indicator parameters, volatile organic compounds [VOC], semivolatile organic compounds [SVOC], polychlorinated biphenyls [PCB], herbicides, kerosene, and total petroleum hydrocarbon [TPH]), radionuclides, and physical properties (moisture content, porosity, calcium carbonate content, specific gravity, dry density, and soil density).

2.4.2.2 216-U-14 Ditch Characterization

Eleven boreholes (299-W18-33, 299-W18-250, 299-W18-251, 299-W19-1, 299-W19-21, 299-W19-27, 299-W19-91, 299-W19-92, 299-W19-93, 299-W23-16, and 299-W23-17) were drilled adjacent to the 216-U-14 Ditch to evaluate one or more of the following: perched water quality, groundwater quality, soil physical properties, and the extent of contamination in the vadose zone during active operations of the ditch. None of these boreholes were drilled through the ditch. Soil chemistry data from eight boreholes (299-W18-33, 299-W18-250, 299-W18-251, 299-W19-91, 299-W19-92, 299-W19-93, 299-W23-16, and 299-W23-17) were used to evaluate conditions in the vadose zone. The eight boreholes were logged in 1993 with gross gamma, spectral gamma logging tool, or both, to assess the presence of radionuclides. Physical property data were collected from the following five boreholes: 299-W18-33, 299-W18-250, 299-W18-251, 299-W23-16, and 299-W23-17. The physical properties determined were saturated hydraulic conductivity, moisture content, porosity, calcium carbonate content, specific gravity, and soil density.

Six test pits were excavated and sampled in the ditch to determine the vertical extent of radiological and chemical contamination beneath the ditch. The ditch had been interim stabilized (i.e., backfilled to grade). The test pits were excavated to depths of 4.9 to 5.8 m (16 to 19 ft).

Three test pits (216-U-14 WTP-1, WTP-2, and WTP-3) were excavated in conjunction with the backfilling activity in 1992. Six samples were collected from the three pits. The samples were analyzed for Am-241, Co-60, Cs-137, K-40, Pu-238/239, Sr-90, lead-214, and total uranium. Three additional test pits were excavated and sampled in 1993 (216-U-14 ETP-1, ETP-2, and ETP-3). A limited amount of data was available from these additional test pits; however, the results consist of radiological and nonradiological data. Three to six samples were collected from each of the 1993 test pits.

2.4.2.3 Characterization of 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches

A total of 90 sediment grab samples ("mud samples") were collected from the bottom of the 216-Z-1D Ditch in 1959 to investigate transuranic surface contamination (WHC-EP-0707). Samples were collected on 30 m (100-ft) centers in groups of three for the entire length of the ditch. Nine samples were collected from the 216-Z-1D Ditch. The remaining samples were collected from the "234-235" Ditch, which may be an alias for the 216-Z-1D Ditch. The nine samples collected from the 216-Z-1D Ditch were analyzed for total alpha activity and Pu-239. Sample locations are shown in WHC-EP-0707.

Eight sediment samples were collected from the bottom of the 216-Z-19 Ditch during March and April 1976 (WHC-EP-0707). The samples were analyzed for K-40, Sr-89/90, Cs-137, Ce-139, Pu-239, Am-241, and Ra-226. Samples were collected along the entire ditch alignment. Only descriptive locations are available for these samples (e.g., "west bank head," "U-Pond inlet").

As part of the Rockwell Hanford Operations Environmental Surveillance Program, sediment samples were collected from the 216-Z-19 Ditch in 1977, 1978, and 1979 (WHC-EP-0707). One sediment sample was collected in 1977 and four were collected in both 1978 and 1979. Samples were analyzed for a suite of radionuclides including Sr-90, Cs-137, Pu-239/240, and Am-241. Only descriptive locations are available for these samples.

A characterization study was performed to gather surface and near-surface samples from the 216-Z-19 Ditch in 1979. The 216-Z-19 Ditch still was in operation at the time of the study and portions of the ditch contained standing water. A total of 246 samples were collected along nine transects with seven sampling points over the length of the ditch. The transect locations are shown in WHC-EP-0707. Sample intervals generally were 5 to 10 cm (2 to 4 in.) in length, and samples were collected less than 1.0 m (3 ft) below the ditch bottom.

Laboratory analyses were conducted at the Rockwell Laboratory (onsite) and two offsite laboratories (Eberline and Environmental Analysis Laboratory). A portion of the samples was analyzed using a developmental van (Dev Van IA) with portable gamma detectors. As discussed in WHC-EP-0707, the results from the Dev Van IA analysis method are believed to be unreliable for low to moderate levels of transuranic contamination. The detector likely was susceptible to recording background "shine" from nearby areas of higher contamination. The effective minimum detection limits reported for Pu-239/240 and Am-241 were 2,000 pCi/g and 100 pCi/g, respectively. Only laboratory analyses were used in the RI report (DOE/RL-2003-11) to evaluate the concentrations of the radioactive constituents. After the Dev Van IA data are removed, 201 samples remain for the transect investigation. Samples were analyzed for Cs-137, Pu-239/240, Pu-238, Sr-90, and Am-241. Thirteen additional separate surface grab samples were collected from the bottom of the ditch from 16th Street to the delta region entering the 216-U-10 Pond to better characterize the lower dry end of the ditch.

Nineteen boreholes were drilled in the vicinity of the Z-Ditches. Two deep monitoring wells (299-W18-177 and 299-W18-178) were drilled during March and April 1980 to evaluate the vertical distribution of contaminants. Seventeen shallow exploration wells were drilled between February and April 1981 to locate and sample the 216-Z-1D and 216-Z-11 Ditches, which were backfilled. Seventy samples were collected from these boreholes and analyzed for Pu-238, Pu-239/240, and Am-241. As with the transect data described earlier, results from the Dev Van IA detector are not included in the data set. Figure 2-2 indicates the location of these 19 boreholes and boreholes drilled in the upper portion of the 216-Z-1D Ditch.

2.4.2.4 Characterization of the 216-A-25 Gable Mountain Pond

Data from the characterization efforts are presented in the borehole/test pit summary reports and in the 200-CW-1 RI report (DOE/RL-2000-35).

A total of 16 test pits were excavated and sampled at the 216-A-25 Gable Mountain Pond to determine the nature and extent of contamination beneath the waste site. Test pits were excavated to a maximum depth of 7.5 m (25 ft), using a trackhoe. Soil samples were collected directly from the trackhoe bucket. A single borehole was drilled at the site, to a depth of 11.5 m (37 ft). Basalt was encountered at 9.3 m (30.5 ft) and the water table was not encountered at the maximum borehole depth of 11.3 m (37 ft). Sampling was performed for VOCs, SVOCs, PCBs, inorganics, TPHs, general chemistry parameters, and radionuclides.

2.4.2.5 Characterization of the 216-T-26 Crib

Data from the characterization efforts are presented in the borehole/test pit summary reports and in the 200-TW-1 RI report (DOE/RL-2002-42).

Borehole C3102 was drilled and sampled at the 216-T-26 Crib during the 200-TW-1 and 200-TW-2 RI. The borehole was drilled through the 216-T-26 Crib from the ground surface to the water table at depths of approximately 69 m (226 ft). The borehole was drilled to better define stratigraphy and to assess the nature and vertical extent of chemical and radiological contamination, as well as the physical properties of the soil beneath these waste sites.

The borehole was drilled using a cable-tool drill rig. The borehole was advanced to total depth using drive barrels and split-spoon samplers. Split-spoon samplers were used as the primary sampling device for collecting chemical, radiological, and physical property samples; however, the drive barrel occasionally was used to collect moisture samples. The borehole was decommissioned with bentonite and cement after reaching total depth, in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

Soil samples collected from the borehole were screened in the field for indications of contamination and to assist with determining discrete sample locations or depths. Samples were screened for volatile organic contamination, beta-gamma activity, and alpha activity. Field-screening data can be found in BHI-01606, *Borehole Summary Report for Borehole C3102 in the 216-T-26 Crib, 200-TW-1 Scavenged Waste Group Operable Unit* and BHI-01607, *Borehole Summary Report for Boreholes C3103 and C3104, and Drive Casing C3340, C3341, C3342, C3343, and C3344, in the 216-B-38 Trench and 216-B-7A Crib, 200-TW-2 Tank Waste Group Operable Unit*.

Soil samples were collected for chemical and radiological analysis and determination of physical properties. Sample collection was guided by the sample schedule in DOE/RL-2000-38, *200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan*.

Additional details regarding sampling, analysis, and results at the 216-T-26 Crib, including geophysical logging activities, may be found in the RI report for 200-TW-1, 200-TW-2, and 200-PW-5 (DOE/RL-2002-42).

2.5 NATURE AND EXTENT OF CONTAMINATION

This section describes the nature and extent of contamination at representative sites and at analogous sites with sufficient data to support risk evaluation in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU. Contamination, as defined in this section, includes those constituents that are not essential nutrients and that were detected at concentrations above Hanford Site background threshold concentrations at the 90th percentile in DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, and in DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*. Ecology 94-115, *Natural Background Soil Metals Concentrations in Washington State*, also was used for background concentrations where no site-specific background concentrations were available. Comparison to background threshold concentrations was conducted to eliminate sample detects that represent naturally occurring constituents. Constituents with concentrations above background levels and with no available background concentrations also were subjected to a screening process against existing regulatory standards. Nonradiological constituents with concentrations above background were compared to risk-based standards in WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties," and WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection," as reported in or calculated in accordance with Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*. Concentrations exceeding risk-based standards are regarded as evidence of contamination and potential risk, unless information is available that would justify eliminating contaminants from the screening process. Nonradiological constituents remaining after the screening process described above are considered potential contaminants of concern (COC) and are evaluated further.

Promulgated soil-based cleanup levels have not been developed for radionuclides; therefore, radionuclides detected above background are considered potential COCs in this section. They are evaluated further in the risk evaluation.

Additional details regarding the screening process, including the number of detections, the identification of essential nutrients, and the comparison of concentrations to background risk-based standards, are presented in the RI reports (DOE/RL-2000-35, DOE/RL-2002-42, and DOE/RL-2003-11).

The following sections present the nature and extent of contamination at each of the representative sites. Only the vertical extent of contamination was characterized and is presented in this section.

2.5.1 Nature and Extent of Contamination at the 216-U-10 Pond

The following contaminants were detected at the given maximum concentrations from the surface to a depth of 2.0 m (6.5 ft):

Cesium-137	3,994 pCi/g	Europium-154	12 pCi/g
Americium-241	44 pCi/g	Europium-155	1.7 pCi/g
Cobalt-60	16 pCi/g	Uranium-233/234	85 pCi/g
Sodium-22	8.2 pCi/g	Uranium-238	88 pCi/g
Technetium-99	8.8 pCi/g	Uranium-235	1.1 pCi/g
Strontium-90	157 pCi/g	Selenium-79	20 pCi/g
Plutonium-238	22 pCi/g	Uranium-234	33 pCi/g
Plutonium-239/240	75 pCi/g		

Aluminum	31,500 mg/kg	Fluoride	23 mg/kg
Antimony	12 mg/kg	Sulfate	2,360 mg/kg
Cadmium	9.1 mg/kg	Kerosene	76 mg/kg
Chromium	83 mg/kg	Uranium	270 mg/kg
Magnesium	8,240 mg/kg	Nitrogen in nitrate and nitrite	145 mg/kg

Contaminants were detected throughout the vadose zone beneath the 216-U-10 Pond to a maximum depth of approximately 42.6 m (140 ft), at the base of Cold Creek Interval in borehole 299-W23-231. Maximum contaminant concentrations generally are present near the surface in the upper 2.0 m (6.5 ft) of the soil column. The depth to the bottom of the pond was approximately 2.0 m (6.5 ft) when it was actively receiving effluent. Soils above 2.0 m (6.5 ft) are characterized by material used to fill in the pond during decommissioning efforts, sediment from the bottom of the pond, or both. The concentration of these contaminants generally decreases with depth beneath the pond bottom. With few exceptions, radionuclides either were not detected or were detected at concentrations of less than about 2.0 pCi/g at depths greater than 2.0 m (6.5 ft). The exceptions are Tc-99 (maximum 4.6 pCi/g), Sr-90 (maximum 28 pCi/g), U-235 (maximum 2.4 pCi/g), Se-179 (maximum 46 pCi/g), and U-234 (maximum 56 pCi/g).

Below 2.0 m (6.5 ft), the following nonradiological contaminants were found: aluminum (12,900 mg/kg), iron (38,000 mg/kg), potassium (21,100 mg/kg), antimony (13 mg/kg), cobalt (21 mg/kg), cyanide (3 mg/kg), and nitrate/nitrite (126 mg/kg).

The radionuclide logging system (RLS) was used to evaluate the vertical and lateral extent of contamination at the 216-U-10 Pond. Cs-137 and U-235 were the only radionuclides detected above screening levels using this method. In boreholes adjacent to the pond, Cs-137 and U-235 were detected above screening levels. Cs-137 was present at a concentration of 4.3 pCi/g at approximately 0.8 m (2.5 ft) bgs. U-235 was detected 73 m (240 ft) bgs at a concentration of 5 pCi/g.

The contaminants of concern model for the 216-U-10 Pond are shown in Figure 2-6.

2.5.2 Nature and Extent of Contamination at the 216-U-14 Ditch

Soil samples were collected beneath and adjacent to the 216-U-14 Ditch. A combination of two data sets was used to assess the vertical and lateral extent of contamination. Samples were collected directly beneath the ditch to a depth of 5.8 m (19 ft). Contamination was detected from 2.7 to 5.8 m (9 to 19 ft) bgs. The major zone of contamination is from 2.7 to 3 m (9 to 10 ft) bgs, which corresponds to the ditch bottom. Maximum concentrations of radionuclides in this zone were as follows:

Cesium-137	2,228 pCi/g
Americium-241	1.6 pCi/g
Cobalt-60	60 pCi/g
Technetium-99	12 pCi/g
Strontium-90	3.2 pCi/g
Plutonium isotopes	10 pCi/g
Uranium isotopes	350 pCi/g

From 3.0 to 5.8 m (10 to 19 ft), contaminant concentrations generally decrease with depth, as follows: Cs-137 (8.3 pCi/g), Am-241 (1.6 pCi/g), Sr-90 (5.2 pCi/g), antimony-125 (7 pCi/g), and uranium isotopes (49 pCi/g). Sulfide was reported at a maximum concentration of 40 mg/kg at a depth of 5.5 to 5.8 m (18 to 19 ft).

Below 5.8 m (19 ft), K-40 was present at a maximum concentration of 149 pCi/g; Pu-239 at 1.4 pCi/g, Ra-226 at 8.4 pCi/g, and Sr-90 at 4.6 pCi/g.

The distribution of contaminants in the ditch also varies along its length. In general, contaminants with large contaminant distribution coefficients, such as Cs-137 and plutonium isotopes, were detected in higher concentrations near the head end of the ditch just south of 19th Street. Contaminants with moderate to low contaminant distribution coefficients, such as Sr-90, and uranium, were detected in higher concentrations at the lower end of the ditch. The contaminants of concern model for the 216-U-14 Ditch are shown in Figure 2-7.

Antimony was the only metal detected above screening levels. This metal was detected at 3.0 to 5.8 m (10 to 19 ft) bgs in concentrations ranging between 6.1 and 7.0 mg/kg.

2.5.3 Nature and Extent of Contamination in the 216-Z-11 Ditch Area

A summary of the maximum concentrations of contaminants in the Z-Ditches in the zone from 0.6 to 1.2 m (2 to 4 ft) is as follows:

Cesium-137	2.0 pCi/g
Americium-241	3094 pCi/g
Plutonium-238	4,000 pCi/g
Plutonium-239/240	40,000 pCi/g

Following is a summary of the maximum contaminant concentrations found in the zone from 1.2 to 5.3 m (4 to 17.5 ft):

Cesium-137	66,000 pCi/g	Thorium-230	8.4 pCi/g
Americium-241	7,870,000 pCi/g	Radium-226	5,200 pCi/g
Strontium-90	216 pCi/g	Nitrite	43 mg/kg
Plutonium-238	5,500 pCi/g	total petroleum hydrocarbons	27 mg/kg
Plutonium-239	780,000 pCi/g	Aroclor-1254	52 mg/kg
Plutonium-239/240	13,000,000 pCi/g	Aroclor-1260	78 mg/kg

Residual concentrations of pesticides and herbicides used to kill vegetation before backfilling the ditch were detected 2.3 to 3 m (7.5 to 10 ft) bgs. Aroclor-1254 and Aroclor-1260 were reported only at this depth and in concentrations of 52 mg/kg and 78 mg/kg, respectively.

Nitrite and TPH exceeded screening levels in soil samples collected from borehole C3808. Nitrite was detected 3 to 5.3 m (10 to 17.5 ft) bgs with the maximum concentration of 43 mg/kg at a depth of 3 m (10 ft). Concentrations decrease with depth to 5.3 m (17.5 ft). TPH was detected 3.0 to 3.8 m (10 to 12.5 ft) bgs at a concentration of 27 mg/kg.

Molybdenum is the only inorganic metal that exceeded screening levels in soil samples from borehole C3808. It was detected 46 to 47 m (152 to 154.5 ft) bgs at a concentration of 0.82 mg/kg.

Borehole C3808 was logged with a small-diameter gross gamma/passive neutron tool and the RLS to depths of 4.9 m and 68.6 m (16 ft and 225 ft), respectively. The gross gamma and passive neutron detector logging results showed good agreement with the spectral gamma logging data by identifying a major zone of contamination approximately 2.9 m (9.5 ft) bgs.

The 216-Z-11 Ditch is aligned close to the 216-Z-19 Ditch and the lower portion of the 216-Z-1D Ditch. These three ditches are discussed collectively in the RI because of the uncertainty associated with the location of boreholes along these ditches and because they share common boundaries. Details regarding the sampling of these ditches and attendant uncertainties are contained in the RI report (DOE/RL-2002-11). Contamination in the Z-Ditches begins at a depth of about 0.6 m (2 ft). From 0.6 to 1.2 m (2 to 4 ft), there are small amounts of Cs-137 and Sr-90 and significant (40 nCi/g) quantities of Pu-239/240 and Am-241. From 1.2 to 5.3 m (4 to 17.5 ft), the zone of maximum contamination, Pu-239/240 concentration rises to 13,000 nCi/g and Am-241 to 7,870 nCi/g. These very high concentrations of transuranics were reported in the 216-Z-19 Ditch and the 216-Z-1D Ditch. Cesium-137 also is present in significant amounts (66,000 pCi/g). Concentrations of these contaminants decrease with depth. Below 5.3 m (17.5 ft), transuranic contamination is less than 1 pCi/g. The contaminants of concern model for the Z-Ditches are shown in Figure 2-8.

2.5.4 Nature and Extent of Contamination at the 216-A-25 Gable Mountain Pond

Clean fill at the 216-A-25 Gable Mountain Pond ranges in thickness from about 4.0 m (13 ft) in the middle to 0.9 m (3 ft) at the edges of the pond. The following maximum concentrations of contaminants were reported in the zone from the bottom of the clean fill to a depth of 4.6 m (15 ft), which is the most contaminated zone:

Cesium-137	7,180 pCi/g	Strontium-90	58.8 pCi/g
Americium-241	<0.2 pCi/g	Europium-154	<0.2 pCi/g
Cobalt-60	<0.2 pCi/g	Arsenic	33 mg/kg
Plutonium-239/240	<0.2 pCi/g	Cadmium	0.3 mg/kg
Technetium-99	<0.2 pCi/g		

Below this zone, only Sr-90 (to a maximum concentration of 58.8 pCi/L) and Cs-137 (27 pCi/L) were found.

The nature and extent of contaminants are described in the 200-CW-1 RI report (DOE/RL-2000-35). The maximum depth of the field investigation at the 216-A-25 Gable Mountain Pond was 11.5 m (37 ft) bgs. Stratigraphic units encountered during excavation (in descending order) consisted of fill material, pond sediments, the Hanford formation gravel-dominated sequence, and basalt. The top of basalt was encountered at a depth of 9.3 m (30.5 ft) in borehole B8757. The water table was not encountered at the maximum depth of 11.3 m (37 ft) bgs (2.0 m [6.5 ft] into the basalt). Groundwater in Well 699-53-47B was 10 m (33 ft) bgs in 1998 (DOE/RL-99-07, *200-CW-1 Operable Unit RI/FS Work Plan and 216-B-3 RCRA TSD Unit Sampling Plan*).

The maximum thickness of fill material excavated at the pond is 4.0 m (13 ft) at test pit GP-2. This cover thins to the east at test pit GP-9 where it is 0.9 m (3 ft) thick and overlies basalt. Fill material consists mainly of sandy silt to sandy gravel. This fill material was placed over the pond as part of stabilization activities commonly performed on waste sites. The fill material consists of clean soil that forms a barrier to intrusion by humans and many biological receptors and that prevents migration associated with wind and biological intrusion. The original surface of the pond bottom lies beneath fill material along the long axis of the pond between test pits GP-3 and GP-16. It also is present in test pits GP-4, GP-6, and GP-12 (Figure 2-9).

Many of the metal concentrations detected in the pond were near or slightly exceeded background. Cadmium is the main metal contaminant associated with pond bottom sediments. PCBs, diesel-range organics, and waste oil compounds were not found at this waste site.

Six SVOCs and six VOCs were detected sporadically in the vadose zone throughout the waste site. None of the SVOC or VOC concentrations were above the WAC 173-340, "Model Toxics Control Act -- Cleanup," Method B or C cleanup levels for direct contact (see Appendix B for more details).

Radionuclides detected include Am-241, Cs-137, Co-60, Sr-90, Pu-239/240, Tc-99, and Eu-154. The greatest level of contamination at the 216-A-25 Gable Mountain Pond typically is detected and associated with the pond bottom. However, strontium contamination extends to a depth of 11.3 m (37 ft). Contaminant concentration decreases with depth below the pond bottom, with one exception (Sr-90).

Strontium-90 and Cs-137 are the major radiological contaminants at the 216-A-25 Gable Mountain Pond and were the only contaminants detected at depths greater than 4.6 m (15 ft) bgs in significant concentrations. The maximum concentrations of Sr-90 and Cs-137 are 58.8 pCi/g and 7,180 pCi/g, respectively. The maximum activity of Cs-137 was associated with the bottom of the pond. The distribution of Sr-90 does not appear to correlate with a particular stratigraphic horizon and was detected throughout the vadose zone at concentrations ranging from not detected to 58.8 pCi/g. The activities of other radiological contaminants typically were less than 2 pCi/g with few exceptions and commonly were observed at less than 4.6 m (15 ft) bgs.

Cesium-137 was the only man-made radionuclide detected in boreholes adjacent to the 216-A-25 Gable Mountain Pond. Activities ranged between 0.25 and 0.4 pCi/g and typically occurred less than 1.1 m (3.5 ft) bgs. However, a single detection occurred in borehole 699-55-50D at a depth of 1.8 m (59.5 ft).

The contaminants of concern model for the 216-A-25 Gable Mountain Pond are shown in Figure 2-10. The results of the 200-CW-1 RI (DOE/RL-2000-35) at the 216-A-25 Gable Mountain Pond suggest the following.

- During operation, this waste site was a major area of infiltration.
- Effluent has percolated across the thickness of the vadose zone, as determined from the volume of effluent discharged and the distribution of Sr-90.
- The vadose zone is less than 15 m (50 ft) thick and consists of the gravel-dominated sequence of the Hanford formation.
- Cesium-137 and Sr-90 are the highest-activity contaminants identified at the pond.
- Higher levels of Cs-137 (7,180 pCi/g) are detected near the bottom of the pond; concentrations decrease with depth below the pond bottom. The maximum vertical extent of Cs-137 contamination is about 7.6 m (25 ft).

- Strontium-90 was detected throughout the vadose zone. The maximum concentration of 58.8 pCi/g was detected at a depth of (17.5 ft). Concentrations generally decrease with depths greater than 5.3 m (17.5 ft) bgs. Very low levels of contamination (0.5 pCi/g) were detected along the margin of the pond.

- Groundwater has been impacted by discharges to the pond, most notably a UPR of 7,500 Ci of Sr-90 in 1964 (UPR-200-E-34). A Sr-90 groundwater plume currently is located on the northeast side of the pond. The plume shows virtually no movement because the water table is very flat. The plume, which had a maximum concentration of 1,210 pCi/L in 2001, is not expected to move beyond its current location.

- The site no longer receives effluent and has an existing soil cover consisting of sand and gravel that ranges from 0.9 to 4 m (3 to 13 ft) thick.

2.5.5 Nature and Extent of Contamination at the 216-T-26 Crib

The location of the 216-T-26 Crib within the 200 West Area is shown in Figure 2-11. A geological north-south cross section through the 216-T-26 Crib site is provided in Figure 2-12. Most notably, the Cold Creek unit (formerly the Pilo-Pleistocene unit) thins from approximately 13.5 m (45 ft) at the north extreme of the cross section to approximately 6 m (20 ft) at the southern end. The following maximum concentrations of contaminants were reported in the zone from 5.5 to 11 m (18 to 36.5 ft):

Cesium-137	47,900 pCi/g	Uranium-238	21 pCi/g
Americium-241	227 pCi/g	Uranium-233/234	18 pCi/g
Strontium-90	49,100 pCi/g	Bismuth	198 mg/kg
Europium-154	62 pCi/g	Fluoride	168 mg/kg
Europium-155	85 pCi/g	Nitrate	255 mg/kg
Plutonium-239/240	6,320 pCi/g	Phosphate	13 mg/kg
Plutonium-238	35 pCi/g	Total uranium	61 mg/kg

Other than phosphate, contamination was not detected in soil samples from the surface to a depth of 5.5 m (18 ft) bgs at the 216-T-26 Crib. The main zone of radioactive contamination extends from 5.5 to 11 m (18 to 36.5 ft) bgs. This zone is associated with the effluent release point at the waste-site bottom (i.e., contact between the backfill and the gravel-dominated sequence of the Hanford formation) and extends to the approximate top of the sand-dominated sequence of the Hanford formation. The maximum Cs-137 concentration occurs at the top of this zone and generally decreases to 11 m (36.5 ft); however, the maximum concentrations of most contaminants occurred in the lower portion of this contaminated zone 10.4 to 11 m (34 to 36.5 ft) bgs.

The 11 to 24.7 m (36.5- to 94.5-ft) zone contains Co-60 (<0.1 pCi/g), K-40 (18 pCi/g), Tc-99 (1.6 to 4.9 pCi/g), tritium (260 to 2650 pCi/g), total uranium (<10 mg/kg), and actinide decay daughters (Ra-226 and -228). The lower portion of this zone is the approximate top of the Cold Creek unit. Only Tc-99 (2.4 pCi/g) and tritium (3.8 pCi/g) were detected greater than 28.8 m (94.5 ft) bgs. Significant reduction in the levels of contamination is associated with the top of the sand-dominated sequence of the Hanford formation and the Cold Creek unit.

Nonradiological contaminants found in the zone from 11 to 24.7 m (36.5 to 94.5 ft) were ammonia (115 mg/kg), cyanide (8 mg/kg), fluoride (86 mg/kg), nitrate (3070 mg/kg), nitrite (48 mg/kg), and total uranium (9.5 mg/kg).

Below 24.7 m (94.5 ft), nitrate (660 mg/kg), Tc-99 (2.4 pCi/g), and tritium (3.8 pCi/g) were detected.

Cesium-137 was detected with the RLS from the top of the waste zone 5.5 m (18 ft) to a depth of 39 m (128 ft) bgs. Log data indicate that most of the Cs-137 was detected from 5.5 to 27.7 m (18 to 91 ft) bgs and is distributed deeper in the vadose zone toward the south end of the site. Contamination extends laterally beyond the 216-T-26 Crib boundary to the south. The contaminant profile suggests that little contamination is spreading to the north. The lateral and vertical extents of Cs-137 contamination detected in boreholes C3102, 299-W11-70, and 299-W11-82 with the RLS are shown in the 200-TW-1 RI report (DOE/RL-2002-42). The contaminants of concern model for the 216-T-26 Crib are shown in Figure 2-13.

2.6 EVALUATION OF ANALOGOUS WASTE SITES

DOE/RL-96-81 describes the grouping of 200 Areas waste sites based on process. Sites that received waste associated with a certain process were grouped by waste category (e.g., cooling water). The waste categories then were grouped based on more specific process details (e.g., 200-CW-2: S Ponds and Ditches Cooling Water Group, 200-CW-4: T Ponds and Ditches Cooling Water Group, 200-CW-5 U-Pond/Z-Ditches Cooling Water Group, and 200-SC-01: Steam Condensate Group). This streamlining approach was implemented to reduce the amount of characterization and evaluation required to support remedial action decision making. Application of the concept takes into account similarities between waste sites such as waste stream type, discharge history, and geology, as well as the available characterization data, to assess the nature and extent of contamination. The concept builds on the knowledge gained from the characterization of a few waste sites (representative sites) that are indicative of worst case and typical OU conditions. Selection of representative sites generally is based on waste stream inventory, the volume of effluent discharged, and the knowledge gained from previous characterization efforts performed before the RI.

2.6.1 Assignment of Analogous Sites

This section contains the rationale used to align potential analogous waste sites to the representative sites and other characterized waste sites. Key to the logic is the comparison of the characteristics of representative and potential analogous sites as well as the identification of potential remedial alternatives that may apply. Important considerations of the physical system include the following:

- Waste stream received
- Volume of effluent received in relation to the available pore volume for the waste site
- Types and amounts of contaminants received; contaminant inventory
- Waste site size
- Waste site configuration and construction (e.g., crib, trench, UPR)
- Expected distribution of contaminants/nature and extent of contamination
- Neighboring waste sites, structures, or utilities
- Geologic setting
- Potential for hydrologic and contaminant impacts to groundwater.

Figure 2-14 shows the process for evaluating the analogous sites against the representative sites for the RI/FS process through the confirmatory and design sampling processes. The rationale for assigning each waste site to a representative site is presented in Table 2-2.

2.6.2 Analogous Site Groupings

The waste sites included in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU represent 4 of the 23 process-based OUs in the 200 Areas. Based on the analogous group assignment criteria above, five analogous groups have been developed for this FS. Table 2-2 provides a list of the representative sites and analogous sites assigned to each representative site and supporting information for determining how an analogous site compares to the representative site.

The ponds and ditches associated with the 200-CW-2 OU are located south and southwest of the 200 West Area fence line. Cooling water from REDOX (S Plant) percolated through several ponds and ditches. The 200-CW-4 Ponds and Ditches are located in the north end of the 200 West Area. Cooling water from the T Plant percolated through several ponds and ditches. Waste sites in the 200-CW-5 OU received cooling water waste liquid from a number of U Plant and Z Plant facilities located inside the 200 West Area fence line and other facilities, such as the laundry facility located on the east side of the 200 West Area. The 200-CW-CS-1 group encompasses a wide variety of processes in the 200 East and 200 West Areas that generated steam condensate waste. Volumes varied considerably, a function of the process and its longevity. This OU consists of cribs, retention basins, UPRs, and pipelines that received or transported steam condensate from a number of the large processing facilities in the 200 Areas. Large volumes of steam were required to heat or boil process chemistry for effective chemical reactions at REDOX, PUREX, the URP at U Plant, and the isotope recovery programs at B Plant. These sites tend to have significant radiological inventories due to failures or leaks in heating coils.

2.6.2.1 216-U-10 Pond and Analogous Waste Sites

The 216-U-10 Pond has been selected as a representative waste site for the following analogous sites:

216-S-16P Pond	216-B-55 Crib
216-S-17 Pond	216-S-172 Control Structure
216-T-4A Pond	2904-S-160 Control Structure
216-T-4B Pond	2904-S-170 Control Structure
216-U-9 Ditch	2904-S-171 Control Structure
216-U-11 Ditch	207-S Retention Basin
216-S-5 Crib	216-B-64 Retention Basin
216-S-6 Crib	200-E-113 Process Sewer
216-A-6 Crib	UPR-200-E-19
216-A-30 Crib	UPR-200-E-21
216-S-25 Crib	UPR-200-E-29
216-A-37-2 Crib	UPR-200-W-124

Table 2-2 provides a detailed comparison of the representative site and its analogous sites. This table indicates the type and level of contamination; amount of waste received at each site, where known; available soil pore volume; and rationale for inclusion of the analogous site(s). The following general discussion of the rationale for assigning the 216-U-10 Pond as a bounding site for this group of analogous waste sites includes this additional information:

1. *Depth of waste discharge: In boreholes adjacent to the pond, Cs-137 and U-235 were detected above screening levels with Cs-137 (4.3 pCi/g) at approximately 0.8 m (2.5 ft) bgs and U-235 (5 pCi/g), detected 73 m (240 ft) bgs. Within the pond, Cs-137 was detected at 440 pCi/g decayed to 366 pCi/g (in 2002) in the pond bottom to 3 m (0 ft to 10 ft) bgs. Soil samples indicate that the average concentration of Cs-137 is 337 pCi/g. Comparison of the two data sets indicates good correlation between the logging and laboratory data.*

The depth of waste discharge at the four analogous ponds (216-S-16P, 216-S-17, 216-T-4A, and 216-T-4B) is expected to be similar to the 216-U-10 Pond. These are all relatively shallow (to 1.8 m [6 ft]) unlined ponds.

The two ditches (216-U-9 and 216-U-11) also are relatively shallow (to 1.5 m [5 ft]) and unlined, so the depth of waste discharge is expected to be similar to the 216-U-10 Pond.

The seven cribs (216-S-5, 216-S-6, 216-A-6, 216-A-30, 216-S-25, 216-A-37-2, and 216-B-55) are deeper (to 6.4 m [21 ft]), so depth of waste discharge is deeper than at the 216-U-10 Pond.

The four control structures (216-S-172, 2904-S-160, 2904-S-170, and 2904-S-171) are underground concrete structures and extend to a depth of 3.0 m (10 ft), so depth of waste discharge is somewhat deeper than at the 216-U-10 Pond.

The two retention basins (207-S and 216-B-64) are concrete structures extending to a depth of 4.6 m (15 ft), so depth of waste discharge is somewhat deeper than at the 216-U-10 Pond.

The 200-E-113 Process Sewer is a steel pipe buried 2.4 m (8 ft).

The four UPRs (200-E-19, 200-E-21, 200-E-29, and 200-W-124) are surface spills.

2. *Expected distribution of contaminants: Contaminants were detected beneath the 216-U-10 Pond to a maximum depth of about 42.6 m (140 ft). Maximum contaminant concentrations generally are present near the surface in the upper 2.0 m (6.5 ft) of the soil column. The depth to the bottom of the pond was about 2.0 m (6.5 ft) when it was actively receiving effluent. Soils above 2.0 m (6.5 ft) are characterized by material used to fill in the pond during decommissioning efforts, sediment from the bottom of the pond, or both. Cesium-137, Sr-90, Se-79, Pu, and U are the predominant radionuclides detected from the surface to the bottom of the pond with concentrations generally decreasing with depth beneath the pond bottom. With few exceptions, radionuclides either were not detected or were detected at concentrations of less than about 2.0 pCi/g at depths greater than 2.0 m (6.5 ft).*

The distribution of contaminants at the four analogous ponds (216-S-16P, 216-S-17, 216-T-4A, and 216-T-4B) is expected to be similar to the 216-U-10 Pond. These are all relatively shallow (to 1.8 m [6 ft]) unlined ponds.

The two ditches (216-U-9 and 216-U-11) are also relatively shallow (to 1.5 m [5 ft]) and unlined, so the distribution of contaminants is expected to be similar to the 216-U-10 Pond. The ditches received only overflow and were operated for a much shorter period of time, so it is possible that contaminants did not saturate the soil to the same depths as at the 216-U-10 Pond.

The seven cribs (216-S-5, 216-S-6, 216-A-6, 216-A-30, 216-S-25, 216-A-37-2, and 216-B-55) are deeper (to 6.4 m [21 ft]). Because contamination at the 216-U-10 Pond is found much deeper than the point of discharge, it is likely that a similar distribution occurs at the cribs.

The four control structures (216-S-172, 2904-S-160, 2904-S-170, and 2904-S-171) are underground concrete structures and extend to a depth of 3.0 m (10 ft). Waste discharge volumes were lower than at the 216-U-10 Pond, so soils were not likely saturated very much below the point of discharge. It is possible that contaminants did not migrate as far down as at the 216-U-10 Pond.

The two retention basins (207-S and 216-B-64) are concrete structures extending to a depth of 4.6 m (15 ft). Because the only waste discharge was leakage, it is possible that contaminants did not migrate as far down as the 216-U-10 Pond.

The 200-E-113 Process Sewer is a steel pipe buried 2.4 m (8 ft). Because the only waste discharge was leakage, it is possible that contaminants did not migrate as far down as at the 216-U-10 Pond.

The UPRs are surface spills. It is unlikely that contaminant distribution at these sites is similar to the 216-U-10 Pond.

2.6.2.2 216-U-14 Ditch and Analogous Sites

The 216-U-14 Ditch has been selected as a representative waste site for the following analogous sites:

216-S-16D Ditch	200-W-88 Process Sewer
216-T-1 Ditch	200-W-102 Process Sewer
216-T-4-1D Ditch	UPR-200-W-111
216-T-4-2 Ditch	UPR-200-W-112
216-W-LWC Crib	207-T Retention Basin
207-U Retention Basin	216-T-12 Trench
200-W-84 Process Sewer	

Table 2-2 provides a detailed comparison of the representative site and its analogous sites. This table indicates the type and level of contamination; amount of waste received at each site, where known; available soil pore volume; and rationale for inclusion of the analogous site(s). The following general discussion of the rationale for assigning the 216-U-14 Ditch as a bounding site for this group of analogous waste sites includes this additional information:

1. *Depth of waste discharge: Soil data indicate that most of the contamination in the 216-U-14 Ditch is in a 2.7 to 5.8 m (9- to 18.5-ft) zone. RLS data indicate that contamination adjacent to the crib may extend to a depth of about 27.4 m (90 ft) bgs.*

The depth of waste discharge at the four analogous ditches (216-S-16D, 216-T-1, 216-T-4-1D, 216-T-4-2) is similar to the 216-U-14 Ditch. The 216-U-14 Ditch is a 3.0 m (10 ft) deep unlined ditch. The four analogous ditches range in depth from 0.9 m (3 ft) to 3.0 m (10 ft).

The 216-W-LWC Crib is 5.8 m (19 ft) deep, so the depth of waste discharge is deeper than at the 216-U-14 Ditch.

The 207-U Retention Basin Retention basin is 2 m (6.5 ft) deep. The depth of the 207-T Retention Basin is assumed to be similar. Therefore, the depth of waste discharge is similar to the 216-U-14 Ditch.

The three analogous process sewers (200-W-84, 200-W-88, 200-W-102) are all shallow (0.6 m [2-ft]) pipelines and therefore the depth of waste discharge is shallower than at the 216-U-14 Ditch.

The two UPRs (200-W-111 and 200-W-112) are both trenches 3.0 m (10 ft) deep. Therefore, the depth of waste discharge is similar to the 216-U-14 Ditch.

2. *Expected distribution of contaminants: Available data indicate maximum concentrations at 5.8 m (19 ft) are 8.3 pCi/g for Cs-137, 0.39 pCi/g for Pu isotopes (0.39), 1.6 pCi/g for Am-241, and 7 pCi/g for U. Strontium-90 also was detected (between 0.81 and 5.2 pCi/g) beneath the ditch. Maximum concentrations for Sr-90 typically were detected from 3.6 to 4.5 m (12 to 15 ft) bgs.*

Distribution of contaminants from the analogous sites is expected to be less than the 216-U-14 Ditch, because they sent waste to the 216-U-14 Ditch (except the UPR sites that are sludge disposal sites from the 207-U Retention Basin and the 216-W-LWC Crib, which received low-activity laundry waste).

Distribution of contaminants is expected to be similar for the 216-S-16D Ditch.

2.6.2.3 216-Z-11 Ditch and Analogous Waste Sites

The 216-Z-11 Ditch has been selected as a representative waste site for the following analogous sites:

- 216-Z-1D Ditch
- 216-Z-19 Ditch
- 216-Z-20 Crib
- 200-Z Retention Basin
- UPR-200-W-110.

Table 2-2 provides a detailed comparison of the representative site and its analogous sites. This table indicates the type and level of contamination; amount of waste received at each site, where known; available soil pore volume; and rationale for inclusion of the analogous site(s). The following general discussion of the rationale for assigning the 216-Z-11 Ditch as a bounding site for this group of analogous waste sites includes this additional information:

1. *Depth of waste discharge: Contamination was detected beneath the 216-Z-11 Ditch to 12 m (40 ft) bgs. Maximum concentrations are present from 2.3 to 5.3 m (7.5 to 17.5 ft). Contaminants associated with Z-Ditch effluents were not detected below 12.2 m (40 ft). Depth of waste discharge is expected to be similar for the analogous sites.*

Documentation does not indicate contamination extended outside of the 207-Z Retention Basin; therefore, waste is not expected below the 207-Z-Retention Basin.

2. *Expected distribution of contaminants: Americium-241 and Pu were the predominant contaminants detected at the ditch bottom, approximately 2.3 to 2.6 m (7.5 to 8.5 ft) bgs with concentrations of 468 pCi/g and 2,780 pCi/g, respectively. Maximum concentrations of Am-241 (919 pCi/g) and Pu (4,840 pCi/g) were detected about 1.2 m (4 ft) beneath the bottom of the ditch at a depth of 3.7 m (12 ft) bgs. This zone of contamination may represent the bottom of the 216-Z-1D Ditch.*

Distribution of contaminants is expected to be similar for the analogous sites.

Documentation does not indicate contamination extended outside of the 207-Z Retention Basin; therefore, waste is not expected below the 207-Z-Retention Basin.

2.6.2.4 216-A-25 Gable Mountain Pond

The 216-A-25 Gable Mountain Pond has been selected as the representative site for the 207-A North Retention Basin.

Table 2-2 provides a detailed comparison of the representative site and its analogous sites. This table indicates the type and level of contamination; amount of waste received at each site, where known; available soil pore volume; and rationale for inclusion of the analogous site(s). The following general discussion of the rationale for assigning the 216-A-25 Gable Mountain Pond as a bounding site for this group of analogous waste sites includes this additional information:

1. *Depth of waste discharge: The greatest level of contamination at the 216-A-25 Gable Mountain Pond typically is detected and associated with the pond bottom. However, strontium contamination extends to a depth of 11.3 m (37 ft). Contaminant concentration decreases with depth below the pond bottom, with one exception (Sr-90).*

Strontium-90 and Cs-137 are the major radiological contaminants at the 216-A-25 Gable Mountain Pond and were the only contaminants detected at depths greater than 4.6 m (15 ft) bgs in significant concentrations.

A review of associated documentation does not indicate contamination spread outside of the 207-A North Basin.

2. *Expected distribution of contaminants: The maximum concentrations of Sr-90 and Cs-137 are 58.8 pCi/g and 7,180 pCi/g, respectively. The maximum activity of Cs-137 was associated with the bottom of the pond. The distribution of Sr-90 does not appear to correlate with a particular stratigraphic horizon and was detected throughout the vadose zone at concentrations ranging from not detected to 58.8 pCi/g. The activities of other radiological contaminants typically were less than 2 pCi/g with few exceptions and commonly were observed at less than 4.6 m (15 ft) bgs.*

A review of associated documentation does not indicate contamination spread outside of the 207-A North Basin.

2.6.2.5 216-T-26 Crib and Analogous Waste Sites

The 216-T-26 Crib has been selected as a representative waste site for the following analogous sites.

- 216-T-36 Crib
- 200-W-79 Pipeline.

Table 2-2 provides a detailed comparison of the representative site and its analogous sites. This table indicates the type and level of contamination; amount of waste received at each site, where known; available soil pore volume; and rationale for inclusion of the analogous site(s). The following general discussion of the rationale for assigning the 216-T-26 Crib as a bounding site for this group of analogous waste sites includes this additional information:

1. *Depth of waste discharge: Soil data indicate most of the contamination in the 216-T-26 Crib is in a 5.6 m (18.5-ft) zone below the bottom of the crib at 5.5 m (18 ft). RLS data indicate that contamination adjacent to the crib may extend to a depth of about 27.4 m (90 ft) bgs.*

Depth of waste discharge for the 216-T-36 Crib is expected to be significantly lower, because volume discharged was 4 percent of the 216-T-26 Crib volume and did not exceed pore volume. The 200-W-79 Pipeline inventory is included in the 216-T-36 Crib inventory.

2. *Expected distribution of contaminants: Most of the contamination detected in the 216-T-26 Crib is within a 5.6 m (18.5-ft) zone extending from the bottom of the crib at 5.5 to 11 m (18 to 36.5 ft). The maximum concentration of Cs-137 is 47,900 pCi/g; the maximum concentration of Sr-90 is 49,100 pCi/g. With the exception of Tc-99 and nitrate, little contamination was detected greater than 11 m (36.5 ft) bgs. The maximum Tc-99 concentration below 11 m (36.5 ft) is 4.9 pCi/g.*

Distribution of contaminants is expected to be lower for the 216-T-12 Trench, based on the form of material disposed (sludge vs. liquid).

Distribution of contaminants for the 216-T-36 Crib is expected to be significantly lower, because volume discharged was 4 percent of the 216-T-26 Crib volume and did not exceed pore volume. The 200-W-79 Pipeline inventory is included in the 216-T-36 Crib inventory.

The effluent volume discharged and the form of material disposed suggest minimal impact to groundwater is expected for the 216-T-12 Trench.

2.7 SUMMARY OF RISK ASSESSMENT

The risk assessment performed for this feasibility study (FS) addresses human receptors, ecological receptors, groundwater protection, and potential intruders to support remedial recommendations discussed in Chapter 8.0. A summary of these assessments and their use in the FS are as follows.

Risk Scenario or Element	FS Application*	Section in which Detail Discussion is Provided	Comments
Industrial land-use scenario	Supports setting cleanup levels	2.7.2	Conceptual exposure model formulated for shallow zone soils, 0 to 4.6 m (0 to 15 ft)
Ecological assessment	For information and comparison purposes to support decision making	2.7.3	Screening-level ecological risk assessment performed. Compares contaminants in shallow zone soils, 0 to 4.6 m (0 to 15 ft) with concentration protective of terrestrial populations
Groundwater protection assessment	For information and comparison purposes to support decision making	2.7.4	Screening-level and detailed analysis performed (if indicated by screening-level analysis) for deep-zone soils (zero to water table)
Intruder scenario	For information and comparison purposes to support decision making	2.7.5	Risk to a future (150 years from present) potential intruder are calculated

*"Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area" (Klein et al. 2002), and *Report of the Exposure Scenarios Task Force* (HAB 2002).

A common requirement in the assessments is a conceptual exposure model. The conceptual exposure model is formulated according to EPA/540/R-99/005, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim,* with the use of professional judgment and information on contaminant sources, release mechanisms, migration routes, potential exposure points, potential exposure pathways, and potential receptor groups associated with the site.

An exposure pathway can be described as the physical course that a contaminant of potential concern takes from the point of release to the receptor. Contaminant intake is the means by which a contaminant of potential concern enters a receptor. For an exposure pathway to be complete, all of the following components must be present:

- A contaminant source
- A mechanism of contaminant release and transport
- An exposure point (i.e., a location where people or wildlife can come into contact with the contaminants)
- An exposure route
- A receptor or exposed population.

In the absence of any one of these components, an exposure pathway is considered incomplete and, by definition, no risk or hazard exists. The conceptual exposure model for the waste sites is presented in Figure 2-15.

Based on the current understanding of land-use conditions at and near the site, the most plausible exposure pathway for characterizing human health risks is the industrial land-use scenario. The industrial land-use scenario is the baseline for evaluation in this FS as agreed by the Tri-Parties (DOE, U.S. Environmental Protection Agency, and Washington State Department of Ecology) (Section 2.7.1, item 6).

Exposure assumptions and methodology used for developing the WAC 173-340 Method B and Method C direct-contact cleanup levels under the residential and industrial land-use scenarios are provided in WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards," and WAC 173-340-745, respectively. The residential scenario is not considered in this FS. In addition, a Native American scenario is not considered because the land use inside the core zone does not include a subsistence scenario.

For the purposes of the risk assessment, the point of compliance for shallow-zone soils is defined as 0 to 4.6 m (0 to 15 ft) bgs. The point of compliance is evaluated using soil samples collected in this zone and is applicable to the industrial use and ecological scenarios. This depth range is a reasonable estimate of the depth of soil that could be excavated and distributed to the surface as a result of development activities. This depth range also is greater than the maximum expected depth of intrusion by biota. The point of compliance for deep-zone soils is defined as those samples collected throughout the soil profile and used to evaluate the protection of groundwater pathways and potential intruders.

The risk assessment for radiological constituents was performed using the Residual Radiation code (RESRAD) Version 6.1 analysis (ANL/EAD-4, *User's Manual for RESRAD, Version 6*). The RESRAD model was used to obtain risk and dose estimates from direct-contact exposure to radiological constituents present in the shallow zone. The RESRAD model also was used to obtain risk and dose estimates for protection of the groundwater pathway based on contaminants in the deep zone. The results obtained from the RESRAD model for the groundwater protection model are limited to screening purposes only. Additional analyses were performed in RI reports using the Subsurface Transport Over Multiple Phases (STOMP) code (PNNL-11216, *STOMP Subsurface Transport Over Multiple Phases Theory Guide*) to evaluate fate and transport of contaminants in the vadose zone to the groundwater. The STOMP-code modeling is presented in DOE/RL-2003-11. The detailed analyses with the STOMP are summarized in Section 2.7.4.3.

Evaluation of the radiological constituents in shallow-zone soil (for the direct-contact exposure pathways) was conducted using two different methods. The first evaluation method is considered representative of current site conditions, because it accounts for the existing clean cover over the waste site (i.e., clean covers have been placed over many waste sites as a part of the surveillance and maintenance program of stabilizing waste sites to prevent intrusion into and migration of contaminants from the sites). The shielding effects of the clean cover influence the resulting dose and risk estimates. The results of evaluation using this method are provided in Section 2.7.2 and Appendix C, Tables C-12 and C-13.

The second evaluation method is considered representative of worst-case conditions; it assumes that no clean cover is present over the top of the representative waste site (i.e., the exposure-point concentration is representative of the entire shallow zone). Under current and future site conditions, onsite industrial workers potentially could be exposed to shallow-zone soils from the site. The results of evaluation using this method are provided in Section 2.7.2 and Appendix C, Tables C-10 and C-11.

The industrial land-use scenario assumes that no groundwater from the waste site will be used for drinking purposes. Standard WAC 173-340 Method C soil cleanup levels for nonradiological constituents consider exposure through the direct-contact pathway (incidental soil ingestion and dermal contact) and inhalation of dust and vapors in ambient air. However, standard Method B equations include incidental soil ingestion as the only potential direct-contact route of exposure. For radiological constituents, potential routes of exposure to shallow-zone soil include external gamma radiation, incidental soil ingestion, and inhalation of dust particulates. Exposure estimates for current and future industrial workers to nonradionuclides are based on standard and consistent assumptions documented throughout Section 2.7 and in Appendix C.

Because constituents are present in the soil column, the protection of groundwater from these constituents is evaluated in the risk assessment considering the deep zone, which is the soil thickness from ground surface to the water table. As noted earlier, groundwater at the waste sites is not used for drinking water purposes. However, exposure assumptions are provided for the groundwater ingestion pathway for evaluating the groundwater protection pathway. The exposure assumptions and methodology used for deriving soil concentrations for groundwater protection are provided in WAC 173-340-747. Soil concentrations of nonradiological constituents protective of groundwater cleanup levels were calculated for the residential and industrial land-use scenarios. For radiological constituents, future impacts to the groundwater ingestion pathway were evaluated.

2.7.1 Tri-Parties Framework

The Tri-Parties developed a framework for risk assessments in the 200 Areas Central Plateau. This process included a series of workshops with representatives from the Tri-Parties, Hanford Advisory Board (HAB), Tribal Nations, the State of Oregon, and other interested stakeholders. The workshops focused on the different programs involved in activities in the 200 Areas Central Plateau and the need for a consistent application of risk assessment assumptions and goals. The results of the risk framework are documented in HAB 132, "Exposure Scenarios Task Force on the 200 Area," in the Tri-Parties response to the HAB advice (Klein et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area"), and in the *Report of the Exposure Scenarios Task Force* (HAB 2002). The following items summarize the risk framework description from the Tri-Parties' response to the HAB.

1. *The core zone (200 Areas including B Pond [main pond] and S Ponds) will have an industrial scenario for the near future. The core zone is depicted in Figure 2-16.*

2. *The core zone will be remediated and closed, allowing for "other uses consistent with an industrial scenario (environmental industries) that will maintain active human presence in this area, which in turn will enhance the ability to maintain the institutional knowledge*

of waste left in place for future generations. Exposure scenarios used for this zone should include a reasonable maximum exposure to a worker/day user, to possible Native American users, and to intruders."

3. *The DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and RAOs. It is anticipated that groundwater contamination under the core zone will preclude beneficial use for the foreseeable future, which is at least the period of waste management and institutional controls (150 years). It is assumed that the tritium and I-129 plumes beyond the core zone boundary will exceed the drinking water standards for the period of the next 150 to 300 years (less for the tritium plume). It is expected that other groundwater contaminants will remain below, or will be restored to, drinking water levels outside the core zone.*

4. *No drilling for water use or otherwise will be allowed in the core zone. An intruder scenario will be calculated for assessing the risk to human health and the environment.*

5. *Waste sites outside the core zone but within the Central Plateau will be remediated and closed based on an evaluation of multiple land-use scenarios to optimize land use, institutional control cost, and long-term stewardship.*

6. *An industrial land-use scenario will set cleanup levels in the 200 Areas core zone. Other scenarios (e.g., residential, recreational) may be used for comparison purposes to support decision making, especially for the following:*

   - The post-institutional controls period (>150 years)
   - Sites near the core zone perimeter, to analyze opportunities to "shrink the site"
   - Early (precedent-setting) closure/remediation decisions.

7. *This framework does not address the tank retrieval decision.*

This description serves as the basis for the risk assessment activities performed as part of this FS. The human health and ecological risk assessments can be found in DOE/RL-2003-11 and in Appendices C and E of this document, and are summarized in the following subsections.

2.7.2 Human Health Risk Assessment

The U.S. Environmental Protection Agency (EPA) *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) cleanup goal is to limit the estimated lifetime risk of excess cancers to 10^{-4} to 10^{-6}. This compares to a baseline risk of approximately 0.2, i.e., approximately 20 percent of the entire U.S. population is expected to die from cancer. CERCLA prescribes this excess risk range over background risk levels. This equates to one in ten thousand to one in a million increase chance of contracting cancer associated with the contamination of the waste site being evaluated. EPA's methodology uses slope factors to convert exposures to chemicals and radionuclides to excess lifetime cancer risk (ELCR). The human health risk assessment included the evaluation of nonradiological and radiological contaminants. These two types of contaminants require separate methods for risk assessment. Nonradiological soil concentrations are compared to risk-based concentrations that are equivalent to an ELCR of 10^{-5} or a hazard quotient less than one. This comparison is done twice; once for exposure to the soil itself and once for exposure to suspended soil particles in the air. Radiological concentrations are modeled with a computer code to determine radiation dose and ELCR.

Because of the risk framework assumption of an industrial use scenario (Section 2.7.1, item 1), only the shallow zone soil, from 0 to 4.6 m [0 to 15 ft] bgs was considered in the assessment. Although all five representative sites (216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch from the 200-CW-5 OU, 216-A-25 Gable Mountain Pond from the 200-CW-1 OU, and 216-T-26 Ditch from the 200-TW-1 OU) currently have a clean cover over the contaminated soil, the risk assessment assumes that this cover either eroded or inadvertently was excavated. Risk results with sufficient cover should produce human health results near background levels. Because radiation can penetrate the soil, radiological risk with cover is calculated for those cases where risk criteria cannot be met in the no-cover configuration.

Local groundwater is not a current source of drinking water and is being addressed under the 200-UP-1 groundwater OU; however, the potential for contaminants to migrate from soil to groundwater was evaluated.

2.7.2.1 Nonradiological Results

The general methodology for the nonradiological risk assessment is to compare the soil concentrations to risk-based concentrations (RBC). For direct contact with the soil, the RBCs are derived from WAC 173-340-745. For inhalation of dust or volatile organics, the RBCs are derived from WAC 173-340-750, "Cleanup Standards to Protect Air Quality."

Comparison to Soil-Based RBCs

The Washington State Department of Ecology has calculated soil cleanup levels based on the WAC 173-340-745 methodology and reported them in CLARC (Ecology 94-145). For those constituents not listed in CLARC, RBCs were calculated based on equations provided in WAC 173-340-745 and WAC 173-340-750 and reasonable exposure assumptions documented in the RI reports (DOE/RL-2000-35, DOE/RL-2002-42, and DOE/RL-2003-11). The *Washington Administrative Code* soil cleanup standards for carcinogens are based on limiting the estimated ELCR to 1×10^{-5}. For noncarcinogens, the standards are selected such that no acute or chronic toxic effects on human health are anticipated, i.e., the hazard quotient is less than one.

The mean concentrations in the four representative sites from 200-CW-5 and 200-TW-1 were compared to the CLARC industrial soil RBCs. For all four representative sites, the mean concentrations of all constituents are below their respective industrial site soil RBCs. The comparisons are provided in Appendix C, Tables C-2 to C-4, for the 200-CW-5 sites. For the 216-T-26 Crib, there were no nonradiological contaminants in the shallow zone that exceeded screening criteria. For the 216-A-25 Gable Mountain Pond site in the 200-CW-1 OU, different comparisons were performed. DOE/RL-2000-35 provides a description of the comparison. As reported in Appendix C, Table C-5, no contaminants exceeded the risk-based values for the 216-A-25 Gable Mountain Pond.

Comparison to Ambient-Air-Based RBCs

The maximum soil concentrations for each contaminant were converted to an air concentration based on a particulate emission factor or a volatile factor, depending on the contaminant. The ambient air concentrations then were compared to their respective RBCs, which were calculated using equations from WAC 173-340-750.

As reported in Appendix C, Tables C-6 through C-8, maximum soil concentration in the three representative sites from 200-CW-5 resulted in air concentrations below the ambient air RBCs for all contaminants. No air-based comparison was available for the 216-T-26 Crib or the 216-A-25 Gable Mountain Pond sites, because as reported in their respective remedial investigation reports, there were no nonradiological contaminants of potential concern.

2.7.2.2 Radiological Results

The radiological risk assessment was performed using the RESRAD code version 6.21 (ANL 2002, *RESRAD for Windows*) developed by Argonne National Laboratory. The RESRAD model was used to obtain risk and dose estimates from direct-contact exposure to radiological constituents present in the shallow zone under an industrial use scenario. The analytical assumptions are based on the industrial use scenario, OU-specific data collected during the RI, state and Hanford Site-specific data from other sources, EPA risk assessment guidance (EPA 1991, *Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)*), and RESRAD defaults. The external gamma, inhalation, and soil ingestion pathways were used to represent the industrial use scenario. The contaminants were modeled as if uniformly distributed within the shallow zone, i.e., upper 4.6 m (15 ft) of the ground surface at concentrations equal to the 95th percent upper confidence level or the maximum, whichever is less. A detailed list of input parameters is provided in Appendix C, Table C-9, of this FS.

The dose rate results were compared to the EPA standard of 15 mrem/yr for members of the public who are unknowingly exposed to radiation. The public dose rate limit was selected because future workers could be unaware of the radioactivity in the soil. This would make them similar to members of the public and not subject to special regulations for radiation workers. Radiation worker must be informed of the radiation hazards and their exposure must be controlled by administrative or engineering controls. This dose rate over a lifetime is approximately equivalent to an estimated ELCR of 1 x 10^{-4}.

> **Dose and Risk**
>
> Dose is a measure of the energy deposited in an individual and the damage incurred by the body by that energy. In this document, dose is measured in millirem. The dose limit suggested by EPA for guiding radiological cleanup is 15 mrem/yr. Risk is a probability of getting cancer. The relationship between dose and risk is approximately linear in EPA's methodology. EPA's range of acceptable risk for CERCLA remediation is 10^{-6} to 10^{-4}.
> The ultimate goal of any CERCLA remediation is to reduce risk to EPA's risk range. For remediation planning and during radiological remediation, the dose limit of 15 mrem/yr is often used as a surrogate for risk.

Dose rates were calculated at various times over a period of 0 to 1,000 years. The outer bound of this period was selected, not because of any applicable regulatory requirement, but because it is a time period often used in DOE analyses. DOE M 435.1-1, *Radioactive Waste Management Manual*, requires 1,000 years for low-level waste performance assessments. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, discusses 1,000 years as a relevant time period for uranium tailing stabilization. Several proposed EPA rules use 1,000 years. Hanford Site CERCLA closures frequently have used a 1,000-year analytical period.

As reported in Table 2-3, the dose rate without a clean cover for four of the five sites exceeds the 15 mrem/yr standard. Only one site, the 216-T-26 Crib, is below the 15 mrem/yr standard because there are no contaminants in the shallow zone. For three representative sites, this condition persists well beyond the 150 years of active institutional control. Table 2-4 shows results of the calculation of timeframes to reach human health preliminary remediation goals (PRG) at each representative site, in a no-cover scenario. Given that dose rates exceed the standard, the dose rates were recalculated with clean covers of 0.6 m (2 ft) for the 216-U-10 Pond, 2.7 m (9 ft) for the 216-U-14 Ditch, 1 m (3.3 ft) for the 216-Z-11 Ditch, and 1 m (3.3 ft) for the 216-A-25 Gable Mountain Pond. The 216-T-26 Crib was not modeled because no radionuclides in the shallow zone exceeded background concentrations. Under these conditions, four sites remain under the 15 mrem/yr standard for 1,000 years; however, the 216-Z-11 Ditch dose rate begins to increase rapidly as the cover erodes away. Detailed RESRAD results are provided in Appendix C, Tables C-10 through C-13.

2.7.3 Ecological Risk Assessment

The ecological risk assessment consists of a screening-level ecological risk assessment (SLERA) followed by a more detailed evaluation, as discussed in Section 2.8, to determine whether further evaluation or remedial actions are necessary. This subsection provides the results of the SLERA performed in the RI.

The general methodology of the SLERA is to compare the shallow zone concentrations in the representative sites with soil concentration levels thought to be protective of terrestrial populations. For nonradiological contaminants, the protective soil concentrations (ecological indicator soil concentrations) are taken from WAC 173-340-900, "Tables," Table 749-3 and methods described in WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures." For radiological contaminants, the protective soil concentrations (biota concentration guides) are taken from DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*.

Appendix C, Tables C-14 and C-15, provide the results of these comparisons for nonradiological and radiological contaminants, respectively, for five sites. The SLERA indicates that the concentration of at least one contaminant at four of the five representative waste sites exceeds those concentrations thought to be protective of terrestrial populations, thus requiring further evaluation as described in Section 2.8. Summary SLERA results of all five sites are as follows:

- **216-U-10 Pond** (Representative Site) – The following contaminants exceeded the ecological soil indicator concentrations or biota concentration guides: Cs-137, Sr-90, and selenium. In addition, there was no indicator concentration or biota concentration guide for Eu-152, Np-237, antimony, silver, thallium, or uranium. These contaminants are further evaluated in Section 2.8.

- **216-U-14 Ditch** (Representative Site) – Cesium-137 exceeded its biota concentration guide, but all nonradiological contaminants were below their ecological indicator concentrations. However, antimony and silver did not have indicator concentrations. These contaminants are further evaluated in Section 2.8.

- **216-Z-11 Ditch** (Representative Site) – The following contaminants exceeded the ecological soil indicator concentrations or biota concentration guides: Am-241, Cs-137, Pu-238, Pu-239, Pu-239/240, Ra-226, Th-228, and Sr-90. Aroclor-1254 and Aroclor-1260 exceeded the PCB level of Table 749-3, but more evaluation is necessary to determine the ecological impact. In addition, there was no indicator concentration for boron. These contaminants are further evaluated in Section 2.8.

- **216-A-25 Gable Mountain Pond** (Representative Site) – Arsenic, barium, and selenium exceeded their ecological soil indicators while Cs-137 and Sr-90 exceeded their biota concentration guides. There were no ecological indicators concentrations or biota concentration guides for antimony, thallium, uranium, acetone, methyl ethyl ketone, methylene chloride, phenol, benzyl butyl phthalate, diethyl phthalate, di-n-butyl phthalate, K-40, and Th-228. These contaminants are further evaluated in Section 2.8.

- **216-T-26 Crib** (Representative Site) – No contaminants exceeded ecological soil indicator concentrations or biota concentration guides. The sum of the fractions of radionuclide concentrations divided by biota concentration guides was well below one. There was no indicator concentration for uranium. Uranium is further evaluated in Section 2.8.

Table 2-5 shows results of the calculation of timeframes to reach ecological PRGs at each representative site.

2.7.4 Protection of Groundwater

The industrial-use framework of the risk assessment (Section 2.7.1, items 1 and 4) precludes use of groundwater in the 200 Areas for drinking purposes. Therefore, the groundwater pathway has not been included in the human health risk assessment. Nevertheless, the Tri-Parties are interested in protecting the waters of the state of Washington. Accordingly, the existing contamination has been analyzed for its potential impact on groundwater. The analytical results are expressed in terms of human health risk to provide a context for interpreting the results. Nonradiological impacts to groundwater are provided as concentrations for comparison to the maximum contaminant levels (MCL) of EPA's drinking water standards in 40 CFR 141, "National Primary Drinking Water Regulations." Radiological impacts to groundwater are provided as dose rates from drinking the water. This analytical endpoint facilitates comparison to the EPA drinking water standard of 4 mrem/yr as stated in 40 CFR 141.

The analysis for protection of groundwater was performed at two levels: a screening level and a detailed level. For the screening-level analysis, the nonradiological contaminant mean concentrations were compared to soil RBCs for protection of groundwater found in the CLARC tables (Ecology 94-145). RESRAD was used to calculate groundwater impacts from radiological contaminants. For the detailed level analysis, STOMP (PNNL-12034, *STOMP, Subsurface*

Transport Over Multiple Phases, Version 2.0, User's Guide) was used to provide more rigorous modeling of radiological and nonradiological contaminants. Details of the STOMP modeling for representative sites (the 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch) are provided in DOE/RL-2003-11, Chapter 4.0.

2.7.4.1 Nonradiological Screening

The deep zone soil mean concentrations were compared to the CLARC groundwater protection values with the comparison results reported in Appendix C, Tables C-16 through C-19. The CLARC values were derived from equations in WAC 173-340-747. Summary conclusions are as follows:

- **216-U-10 Pond** – Cadmium exceeds its soil RBC by 30 percent, manganese exceeds its soil RBC by a factor of 8, and uranium exceeds its soil RBC by a factor of 15. All other contaminant concentrations were below their respective RBCs.

- **216-U-14 Ditch** – All contaminant concentrations are below their respective soil RBCs.

- **216-Z-11 Ditch** – Aroclor-1254 exceeds its soil RBC by a factor of 4.7 and nitrite exceeds its soil RBC by a factor of 2.5. All other contaminant concentrations were below their respective RBCs.

- **216-A-25 Gable Mountain Pond** – The true mean concentrations for all constituents are less than their respective WAC 173-340 Method C cleanup levels, as described in the 200-CW-1 OU RI report (DOE/RL-2000-35).

- **216-T-26 Crib** – The one sample for uranium exceeds its soil RBC by 36 percent. All other contaminants are below their respective RBCs (based on shallow zone samples).

2.7.4.2 Radiological Screening

The maximum of either the shallow zone or deep zone (0 m to water table) mean soil concentrations of each radionuclide contaminant were used for RESRAD screening of groundwater impacts. All contaminants were modeled as if uniformly distributed in the top few meters of the soil without soil cover (the depth of the contaminated zone depending on the contaminant distribution in each location). The use of mean values is appropriate because the uniform distribution assumption, in effect, averages the hot spots over a large region.

Details are provided in Appendix C, Tables C-20 and C-21 for the 200-CW-5 and 200-TW-1 OU sites. Only the 216-U-10 Pond and the 216-U-14 Ditch produced groundwater contamination that exceeded both the 4 mrem/yr drinking water standard and the 1×10^{-5} ELCR criterion. The most significant contaminants were Se-79 for the 216-U-10 Pond and Tc-99 for the 216-U-14 Ditch. By the time institutional control is assumed to be lost (at 150 years), groundwater concentrations from the two sites drop below the 4 mrem/yr standard.

2.7.4.3 Detailed STOMP Modeling

The contaminants used in the STOMP modeling were selected based on the nonradiological and RESRAD screening reported in Sections 2.7.4.1 and 2.7.4.2 in addition to other contaminants determined by regulatory considerations and scientific judgment. The list of analyzed contaminants is provided in Appendix C, Table C-22. The modeling used more detailed knowledge of contaminant distributions and subsurface conditions. Table 2-6 identifies the contaminants that STOMP predicated would exceed MCLs in the groundwater and indicates the time required for the groundwater contamination at each representative site, under natural attenuation, to reduce to acceptable levels. The results are summarized as follows:

- **216-U-10 Pond** – The following contaminants exceed their MCLs at some time during the 1,000-year period of analysis: Se-79, Tc-99, cyanide, fluoride, total uranium, U-233, U-234, U-235, U-238, and sulfate. Uranium concentrations continue to rise after 1,000 years.

- **216-U-14-Ditch** – The following contaminants exceed their MCLs at some time during the 1,000-year period of analysis: Tc-99, uranium isotopes, and sulfide. Uranium concentrations continue to rise after 1,000 years.

- **216-Z-11 Ditch** – No contaminants reach the groundwater within the 1,000-year period of analysis.

- **216-A-25 Gable Mountain Pond** – Detailed analysis with the STOMP code is not required because, based on screening analysis (Appendix C, Table C-20), potential groundwater impacts from radionuclides during the period of interest do not exceed the EPA drinking water standard of 4 mrem/yr (40 CFR 141).

- **216-T-26 Crib** – The following contaminants exceed their MCLs at some time during the 1,000-year period of analysis: cyanide, nitrate, nitrite, Tc-99, and U-233/234/238.

2.7.5 Intruder Risk Assessment

The inadvertent intruder scenario is based on the possibility that, after the 150 years, an individual unwittingly (through human error or loss of knowledge concerning the location of contaminants) engages in an activity that results in contact with wastes left in place. The goal of remediation is to reduce the estimated ELCR to the range of 10^{-4} to 10^{-6}, using a dose of 15 mrem/yr above background as an operational guideline to achieve this goal. The evaluation in this risk assessment focuses on the 15 mrem/yr standard.

Appendix E contains the intruder risk analysis. Three intruder scenarios (described in Appendix E) were proposed for evaluation:

- Future construction trench worker
- Future well driller
- Future rural resident.

Of the three scenarios proposed for evaluation, the third is considered the worst-case scenario, primarily because of the larger exposure time. Therefore, the third scenario is the only one analyzed in Appendix E. This scenario assumes that a receptor is residing within the area and has planted a garden using the drill cuttings taken from a well drilled through the waste site. The resident receives dose from direct exposure to the radiation field in the garden, inhales resuspended dust, ingests soil, and consumes garden produce grown in the contaminated soil. Consumption of groundwater is not included in this evaluation, because groundwater in this area currently is under remediation and is not available for use. This scenario is consistent with other inadvertent intruder evaluations conducted within the Central Plateau.

Table 2-7 summarizes the results of the intruder analysis for both a 150- and 500-year period of institutional control. Assuming no excavation of contaminated soil, this table shows two representative sites where an intruder scenario at 150 years exceeds 15 mrem/yr at the 216-Z-11 Ditch and the 216-T-26 Crib.

2.8 EVALUATION OF ECOLOGICAL SIGNIFICANCE

The screening-level ecological risk assessment (Section 2.7.3) indicated that concentrations of one or more chemicals exceeded ecological screening values at four of the five waste sites. This section evaluates the ecological significance of contamination at each site.

The bald eagle (*Haliaeetus leucocephalus*), Federally listed as threatened, is the only species listed under the federal *Endangered Species Act of 1973* that has been observed at the Hanford Site. Previous reports have included the Aleutian Canada goose (*Branta canadensis leucopareia*) as a Federally threatened species known to occur at the Hanford Site; however, this species has largely recovered and was delisted in March 2001. It is no longer a Federally listed species (USFWS 2004, *Threatened and Endangered Species System, Delisted Species Information*). Both the bald eagle and the Aleutian Canada goose are birds that occur along the Columbia River corridor and rarely are seen in the Central Plateau. Thus, site-related contamination at the 200-CW-5 OU sites does not pose potential risk to Federally listed species.

Four other bird species classified by the Washington Department of Fish and Wildlife as "species of concern" also have been reported to occur at the Hanford Site (WDFW 2004, *Species of Concern in Washington State)*. These species consist of the ferruginous hawk (*Buteo regalis*), state-listed as threatened, and the burrowing owl (*Athene cunicularia*), loggerhead shrike (*Lanius ludovicianus*), and sage sparrow (*Amphispiza belli*). The burrowing owl, loggerhead shrike, and sage sparrow are each listed as "state candidate" species (WDFW 2004). Because the cover of clean soil at the five sites prevents exposure to site-related contaminants by the ferruginous hawk, loggerhead shrike, and sage sparrow, site-related potential risk to these three state-listed species is negligible. Site-related potential risk to the burrowing owl is discussed below. No other plants, invertebrates, amphibians, reptiles, or mammals that are Federally listed or listed by the State of Washington as threatened or endangered species are known to exist in the Central Plateau.

Under WAC 173-340, a distinction is made between commercial or industrial property and other types of land use. For commercial or industrial property, only potential exposure pathways to wildlife need to be considered (i.e., potential risks to soil invertebrates and plants do not have to be evaluated at a commercial or industrial property). The 200-CW-5 OU sites are in an industrial area as defined in WAC-173-340-200, "Definitions." Therefore, the following discussion is limited to wildlife-related potential risks.

2.8.1 216-U-10 Pond

The pond covers approximately 12 ha (30 a) and is covered by clean soil at an average depth of 0.6 m. Concentrations of Cs-137, Sr-90, and selenium exceeded ecological guidelines (Appendix C, Tables C-14 and C-15) in some samples, and there were no ecological guidelines for Se-79, Eu-152, Np-237, antimony, cyanide, silver, thallium, uranium, diethylphthalate, di-n-butylphthalate, or toluene, which were detected in some samples. The overlying soil cover prevents exposure to site-related contaminants by most wildlife species. However, burrowing mammals, such as the badger, coyote, northern pocket gopher, deer mouse, Great Basin pocket mouse, and burrowing owl, if present, could be exposed to site-related contaminants. In summary, uncertainty exists regarding the potential risk to burrowing animals that might occur on the site, but the 0.6 m cover prevents exposure to site-related contaminants by most wildlife species.

2.8.2 216-U-14 Ditch

The ditch encompasses approximately 1.3 acres. The concentration of Cs-137 exceeded the ecological guideline (Appendix C, Table C-15). Like the 216-Z-11 Ditch, the 216-U-14 Ditch is a narrow linear feature. It would be highly unlikely that any individual animal would use *only* the ditch for foraging, shelter, etc. Thus, exposure to contaminants in the ditch probably would be minor relative to the entire area used by an animal. Furthermore, the ditch is completely covered by clean soil at an average depth of 2.7 m, precluding exposure to site-related contaminants by all species except those that are fossorial. Cesium-137 was the only radiological contaminant that exceeded its biota concentration guide, and no nonradiological chemicals exceeded their ecological guideline concentrations. The small size of the site and the 2.7 m soil cover serve to minimize the exposure pathway. Therefore, the potential for ecological impacts from site-related contaminants is negligible.

2.8.3 216-Z-11 Ditch

The ditch encompasses approximately 0.24 acres. Although concentrations of Am-241, Cs-137, Pu-238, Pu-239, Pu-239/240, Ra-226, and Sr-90 exceeded ecological guidelines (Appendix C, Table C-15), this site is a relatively small area that has a narrow linear footprint characteristic of a ditch, and the contaminated area typically would comprise only a small portion of an animal's home range (i.e., it would be highly unlikely that any individual animal would use *only* the ditch for foraging, shelter). Thus, exposure to contaminants in the ditch would tend to be minor relative to the entire area used by an animal. Furthermore, the contaminated area is completely covered by clean soil at an average depth of 1.2 m. The overlying cover effectively precludes exposure to contaminants for almost all receptor species. Burrowing mammals such as the badger (*Taxidea taxus*), coyote (*Canis latrans*), northern pocket gopher (*Thomomys talpoides*), deer mouse (*Peromyscus maniculatus*), and Great Basin pocket mouse (*Perognathus parvus*) might be exposed to site-related contaminants. Similarly, the burrowing owl (*Athene cunicularia*), a species that nests in abandoned badger or coyote burrows, might be exposed to site-related contaminants. As mentioned above, however, use of the ditch by burrowing animals probably would be minimal. In summary, the 1.0 m cover, small areal extent, and linear nature of the site reduces the extent to which wildlife species would be exposed to site-related contaminants, and potential site-related risk is probably negligible.

2.8.4 216-A-25 Gable Mountain Pond

The pond covers approximately 29 ha (71 a) and is covered by clean soil at an average depth of 0.9 m. Concentrations of metals such as arsenic, barium, and selenium, and Cs-137 and Sr-90 exceeded their guidelines in samples. Thirteen contaminants had no ecological guidelines. They included 11 nonradionuclides and 9 volatile and semivolatile compounds (Appendix C, Table C-14), and two radionuclides (K-40 and Th-228) (Appendix C, Table C-15). The overlying soil cover prevents exposure to site-related contaminants by most wildlife species. However, burrowing mammals such as the badger, coyote, northern pocket gopher, deer mouse, Great Basin pocket mouse, and burrowing owl, if present, could be exposed to site-related contaminants. In summary, concentrations of five contaminants exceeded ecological guidelines, and there is uncertainty regarding the potential risk posed by these five contaminants to burrowing animals that might occur on the site. However, the 0.9 m cover prevents exposure to site-related contaminants by most wildlife species.

2.8.5 216-T-26 Crib

The crib encompasses only 0.02 acres and is located in a highly developed portion of the Hanford Site. The contaminated area is completely covered by 5.5 m of clean soil. The developed nature of the area, the small size of the site, and the soil cover result in an exposure pathway that is essentially incomplete. Furthermore, no contaminants at this site exceeded available ecological guidelines (Appendix C, Tables C-14 and C-15). Therefore, the potential for ecological impacts from site-related contaminants is negligible. The uncertainty resulting from the lack of an ecological screening guideline for total uranium, which was detected at the site, is minimal.

2.8.6 Conclusions

The 216-Z-11 Ditch, 216-U-14 Ditch, and 216-T-26 Crib are sites whose total areal extents are miniscule, providing little opportunity for use by terrestrial receptors. Furthermore, few contaminants were present in the soil samples at the 216-U-14 Ditch and 216-T-26 Crib, and the 216-T-26 Crib is located in a highly developed portion of the Hanford Site. In addition, each of these three sites is covered by clean soil (216-Z-11 Ditch: 1.2 m; 216-U-14 Ditch: 2.7 m, 216-T-26 Crib: 5.5 m). For these reasons, potential risk posed by the 216-Z-11 Ditch, 216-U-14 Ditch, and 216-T-26 Crib is negligible, both for the individual sites as well as the cumulative risk of all three sites as a whole.

The 216-U-10 Pond and the 216-A-25 Gable Mountain Pond are large enough so that exposure to soil contaminants by burrowing animals cannot be ruled out. Some contaminants, primarily Cs-137 and Sr-90, could pose risk to burrowing animals, but the extent to which burrowing animals use these two sites is not clear. The overlying clean soil covers at these two sites (0.6 m at 216-U-10 and 0.9 m at the 216-A-25 Gable Mountain) essentially preclude exposure by non-burrowing animals. Screening-level shielding calculations indicate that gamma rays are greatly attenuated in passing through the clean cover, yielding insignificant external dose rates at the surface. It should be pointed out that 216-U-10 Pond site is in an industrial areas. Land use and habitat types at this site is not expected to change significantly in the future.

The uncertainty associated with risks to burrowing animals at the 216-U-10 Pond and the 216-A-25 Gable Mountain Pond is not great and would be acceptable if the selected remediation were capping or source removal. If no action were selected as the remedial alternative for these two sites, then additional ecological investigation and assessment focused on impact to and from burrowing animals would be required. If the remedial alternative selected is to provide a surface barrier (cap), then it is assumed that any burrowing animals present at the sites would be removed before remediation. It also is assumed that the additional thickness of material over the contaminants provided by the cap and inherent intrusion deterrent features designed into the cap would be an adequate deterrent to potential future populations of burrowing animals and no further ecological investigation or assessment would be required. Likewise, no additional ecological investigation or assessment would be required at these two sites if the selected remedial alternative were source removal. Additional ecological risk evaluations are not recommended at this time for the other three representative sites, considering the contaminant concentrations, site configurations, potential wildlife populations near the sites, and current and future expected land use as discussed in this section.

2.9 REPRESENTATIVE WASTE SITES RISK ASSESSMENT SYNOPSIS

Table 2-3 summarizes the risks at the representative sites, based on the human health risk assessment and SLERA found in the applicable RI reports and Appendix C of this FS. Tables 2-4 and 2-5 summarize the timeframes to reach human health and ecological PRGs (PRGs are discussed in Chapter 3.0; comparisons to risk-based standards [which become PRGs in Chapter 3.0] are performed in the RI report and in Appendix C) through natural radioactive decay at each representative site. The tables support the determination of appropriate alternatives to be evaluated for each representative site and its associated analogous waste sites.

2.9.1 Application to the 216-U-10 Pond and its Analogous Waste Sites

The depth to the bottom of the 216-U-10 Pond was approximately 2.0 m (6.5 ft) when it was actively receiving effluent. Soils above 2.0 m (6.5 ft) are a combination of fill material and pond sediment and contain fission products, transuranics radionuclides, and chemical contaminants. Concentrations of these contaminants generally decrease with depth below the pond bottom and sporadically are present in the vadose zone to a maximum depth of 43 m (140 ft). Because effluent volume discharged to the 216-U-10 Pond was greater than the soil column pore volume, it is likely that some contamination reached the aquifer groundwater during site operations. PNNL-13788 indicates that mobile contaminants (nitrate, carbon tetrachloride, and uranium) exceed groundwater protection standards near the pond. Nitrate and uranium may be associated with waste disposal practices at the pond as well as at other waste sites in the 200 West Area.

As shown in Table 2-3, the following are applicable to vadose zone contamination at the 216-U-10 Pond.

- With respect to radiological contaminants in the 0 to 4.6 m (0- to 15-ft) zone, human health is not protected in the no-cover case because the dose (2,700 mrem/yr) exceeds the PRG (15 mrem/yr); however, if the existing cover soil is taken into account, the dose is reduced to negligible levels under existing conditions. In 150 years, dose decays to 95 mrem/yr in the no-cover case, still above the PRG.

- With respect to nonradionuclides, human health is protected because contaminant concentrations in this zone do not exceed WAC 173-340-745 risk-based standards.

- Groundwater is not protected because STOMP modeling predicts that cyanide, fluoride, total uranium, Se-79, Tc-99, U-233/234, U-235, and U-238 may reach the groundwater above MCLs or risk-based standards under the no-action scenario.

- Ecological receptors (burrowing animals) at the 216-U-10 (U Pond) site are not protected because the thickness of the existing clean soil cover (0.6 m) is not sufficient to rule out exposure to soil contaminants by burrowing animals. Cesium-137, Sr-90, and selenium were encountered above PRGs and could pose risk to burrowing animals, but the extent to which burrowing animals use these two sites is not clear. The overlying clean soil cover essentially precludes exposure by non-burrowing animals. Screening-level shielding calculations indicate that gamma rays are greatly attenuated in passing through the clean cover, yielding insignificant external dose rates at the surface. Additionally, the site is in industrial areas; land use and habitat types are not expected to change significantly in the future.

- With respect to intruders to the waste sites past the 150-year active institutional control period, human health is protected, because the intruder analysis (Appendix E) shows that the maximum intruder dose will be 2.8 mrem/yr, which is below the goal of 15 mrem/yr.

2.9.2 Application to the 216-U-14 Ditch and its Analogous Waste Sites

Neither radiological nor nonradiological contaminants were encountered above background from the surface to a depth of 2.7 m (9 ft) at the 216-U-14 Ditch. Contamination was detected below 2.7 m (9 ft). The major zone of contamination is from 2.7 to 3 m (9 to 10 ft), which corresponds to the original ditch bottom elevation. Contamination in this zone includes fission products, transuranic radionuclides, and Co-60 (an activation product). Contamination generally decreases with depth. Because effluent volume discharged to the 216-U-14 Ditch was greater than the soil column pore volume, it is likely that some contamination reached the aquifer groundwater during site operations.

The distribution of contaminants in the 216-U-14 Ditch varies along its length. In general, contaminants with high distribution coefficients (cesium, plutonium) were detected at higher concentrations near the head end of the ditch. Contaminants with moderate or low distribution coefficients (strontium, uranium) were detected in high concentrations at the lower end of the ditch.

As shown in Table 2-3, the following are applicable to vadose zone contamination at the 216-U-14 Ditch:

- With respect to radiological contaminants in the 0 to 4.6 m (0- to 15-ft) zone, human health is not protected because the dose (1,400 mrem/yr) exceeds the PRG (15 mrem/yr); however, if the existing cover soil is taken into account, this dose is reduced to negligible levels. In 150 years, dose decays to 47 mrem/yr in the no-cover case, still above the PRG.

- With respect to nonradionuclides, human health is protected, because contaminant concentrations in this zone do not exceed WAC 173-340-745 risk-based standards.

- Groundwater is not protected because STOMP modeling predicts that sulfide, U-233/234, U-235, U-238, and Tc-99 may reach the groundwater above MCLs or risk-based standards under the no-action scenario.

- Ecological receptors are protected. Although Cs-137 concentrations exceed the PRG at the 216-U-14 Ditch, exposure to contaminants in the ditch would tend to be minor because the ditch encompasses a relatively small area and has a narrow linear shape such that the contaminated area would comprise only a small portion of an animal's home range (i.e., it would be highly unlikely that any individual animal would use only the ditch for foraging, shelter).

- With respect to intruders to the waste sites past the 150-year active institutional control period, human health is protected, because the intruder analysis (Appendix E) shows that the maximum intruder dose will be 1.8 mrem/yr, which is below the goal of 15 mrem/yr.

2.9.3 Application to the 216-Z-11 Ditch and its Analogous Waste Sites

The 216-Z-11 Ditch is close to the 216-Z-19 Ditch and the lower portion of the 216-Z-1D Ditch. These three ditches are discussed collectively in the RI report (DOE/RL-2003-11) because of the uncertainty associated with the location of boreholes along these ditches and because they share common boundaries. These three ditches are collectively discussed as the "Z-Ditches" below.

Contamination in the Z-Ditches begins at a depth of about 0.6 m (2 ft). Transuranic radionuclide concentrations exceed 100 nCi/g down to a depth of 3 m (10 ft). Levels of transuranic contamination less than 100 nCi/g, along with fission product contamination, continue to a depth of 5.3 m (17.5 ft) bgs. Cesium-137 also is present in significant amounts (66,000 pCi/g). Concentrations of these contaminants decrease with depth. Below 5.3 m (17.5 ft), transuranic contamination is less than 1 pCi/g.

The effluent volume discharged to the Z-Ditches is unknown; therefore, impacts to groundwater are unknown. The Z-Ditches mainly were used to channel wastewater rather than to percolate it, so infiltration beneath the Z-Ditches probably was very limited.

Surface and near-surface soil data suggest that radioisotopes are distributed over the entire length of the ditches. Significant variability in concentrations reported for closely spaced samples would make it difficult to confidently segregate portions of the ditch as hot spots relative to other less contaminated areas.

As shown in Table 2-3, the following are applicable to vadose zone contamination at the 216-Z-11 Ditch:

- With respect to radiological contaminants in the 0 to 4.6 m (0- to 15-ft) zone, human health is not protected because the dose (45,000 mrem/yr) exceeds the PRG (15 mrem/yr); however, if the existing cover soil is taken into account, this dose is reduced to negligible levels. In 150 years, dose decays to 42,000 mrem/yr in the no-cover case, still above the PRG.
- With respect to nonradionuclides, human health is protected because contaminant concentrations in this zone do not exceed WAC 173-340-745 risk-based standards.
- Groundwater protection is not required because vadose zone modeling does not predict chemicals or radionuclides to reach groundwater above MCLs.
- Ecological receptors are protected. Although concentrations of Am-241, Cs-137, Pu-238, Pu-239, Pu-239/240, Ra-226, and Sr-90 exceed the PRGs at the 216-Z-11 Ditch, exposure to contaminants in the ditch would tend to be minor because the ditch encompasses a relatively small area and has a narrow linear shape such that the contaminated area would comprise only a small portion of an animal's home range (i.e., it would be highly unlikely that any individual animal would use only the ditch for foraging, shelter).
- With respect to intruders to the waste sites past the 150-year active institutional control period, human health is not protected, because the intruder analysis (Appendix E) shows that the maximum intruder dose will be 25 mrem/yr, which is above the goal of 15 mrem/yr. In addition, intruder analysis of the analogous waste sites shows that human health is not protected at the 216-Z-1D Ditch (3.3×10^3 mrem/yr) nor at the 216-Z-19 Ditch (5.5×10^3 mrem/yr).

2.9.4 Application to the 216-A-25 Gable Mountain Pond and its Analogous Waste Site

The depth to the original bottom elevation of the 216-A-25 Gable Mountain Pond is approximately 4.0 m (13 ft) below present grade in the middle, thinning to the surface at the edge. A basalt formation is at the surface at the south side of the pond, sloping down to a depth of 10.6 m (35 ft) at the north side. Maximum depth of field investigations at the 216-A-25 Gable Mountain Pond was 11.5 m (37 ft). In 1998, groundwater was encountered at 10 m (35 ft).

Strontium-90 and Cs-137 are the major radiological contaminants below the 216-A-25 Gable Mountain Pond. Cesium-137 is present from 2.8 to 4.4 m (9 to 13 ft) at a concentration of 7000 pCi/g. Below 4.4 m (13 ft), Cs-137 drops to below 30 pCi/g. Strontium-90 levels are below 30 pCi/g from the pond bottom to the basalt layer. Unlike Cs-137, which is concentrated at the pond bottom, Sr-90 is present throughout the vadose zone.

Because effluent discharge volume was much greater than soil pore volume, strontium and other moderately mobile radionuclides entered the groundwater. A Sr-90 groundwater plume (1210 pCi/L) is currently located on the northeast side of the pond but is not expected to move beyond its current location, as discussed in the 200-CW-1 FS (DOE/RL-2002-69).

As shown in Table 2-3, the following are applicable to vadose zone contamination at the 216-A-25 Gable Mountain Pond:

- With respect to radiological contaminants in the 0 to 4.6 m (0- to 15-ft) zone, human health is not protected because the dose (1,100 mrem/yr) exceeds the PRG (15 mrem/yr); however, if the existing cover soil is taken into account, this dose is reduced to negligible levels. In 150 years, dose decays to 11 mrem/yr in the no-cover case, below the PRG.

- With respect to nonradionuclides, human health is protected because contaminant concentrations in this zone do not exceed WAC 173-340-745 risk-based standards.

- Groundwater protection is not required. The true mean concentrations for all constituents are less than their respective WAC 173-340 Method C cleanup levels.

- Ecological receptors are not protected. Ecological receptors (burrowing animals) at the 216-A-25 Gable Mountain Pond site are not protected because the thickness of the existing clean soil cover (0.9 m [3 ft]) is not sufficient to rule out exposure to soil contaminants by burrowing animals. Cesium-137 and Sr-90, arsenic, barium, and selenium were encountered at concentrations greater than the PRGs and could pose risk to burrowing animals, but the extent to which burrowing animals use these two sites is not clear. The overlying clean soil cover essentially precludes exposure by non-burrowing animals. Screening-level shielding calculations indicate that gamma rays are greatly attenuated in passing through the clean cover, yielding insignificant external dose rates at the surface. Additionally, the site is in industrial areas; land use and habitat types are not expected to significantly change in the future.

- With respect to intruders to the waste sites past the 150-year active institutional control period, human health is protected, because the intruder analysis (Appendix E) shows that the maximum intruder dose will be 7.4 mrem/yr, which is below the goal of 15 mrem/yr.

2.9.5 Application to the 216-T-26 Crib

Neither radiological nor nonradiological contaminants above background levels were encountered in the shallow zone at the 216-T-26 Crib. The bottom of the waste site was identified at 5.5 m (18 ft). Significant concentrations of Cs-137 and Sr-90 are located in the zone from 5.5 to 11 m (18 to 36.5 ft). As shown in Table 2-3, the following are applicable to vadose zone contamination at the 216-T-26 Crib.

- With respect to radiological contaminants in the 0 to 4.6 m (0-to 15-ft) zone, human health is protected because there is no contamination in this zone.
- With respect to nonradionuclides, human health is protected because contaminant concentrations in this zone do not exceed WAC 173-340-745 risk-based standards.
- Groundwater is not protected because STOMP modeling predicts that cyanide, nitrate, nitrite, U-233/234, U-238, and Tc-99 may reach the groundwater above MCLs or risk-based standards. Groundwater is not protected because antimony, cadmium, cyanide, nitrate, total uranium, Co-60, Ra-226, Tc-99, and U-238 are predicted to reach the groundwater above MCLs, either through modeling or through comparison to groundwater protection standards.
- Ecological receptors are protected because contaminant concentrations are below screening levels.
- With respect to intruders to the waste sites past the 150-year active institutional control period, human health is not protected, because the intruder analysis (Appendix E) shows that the maximum intruder dose will be 35 mrem/yr, which is above the goal of 15 mrem/yr.

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Figure 2-1. Stratigraphic Column for the 200 Areas.

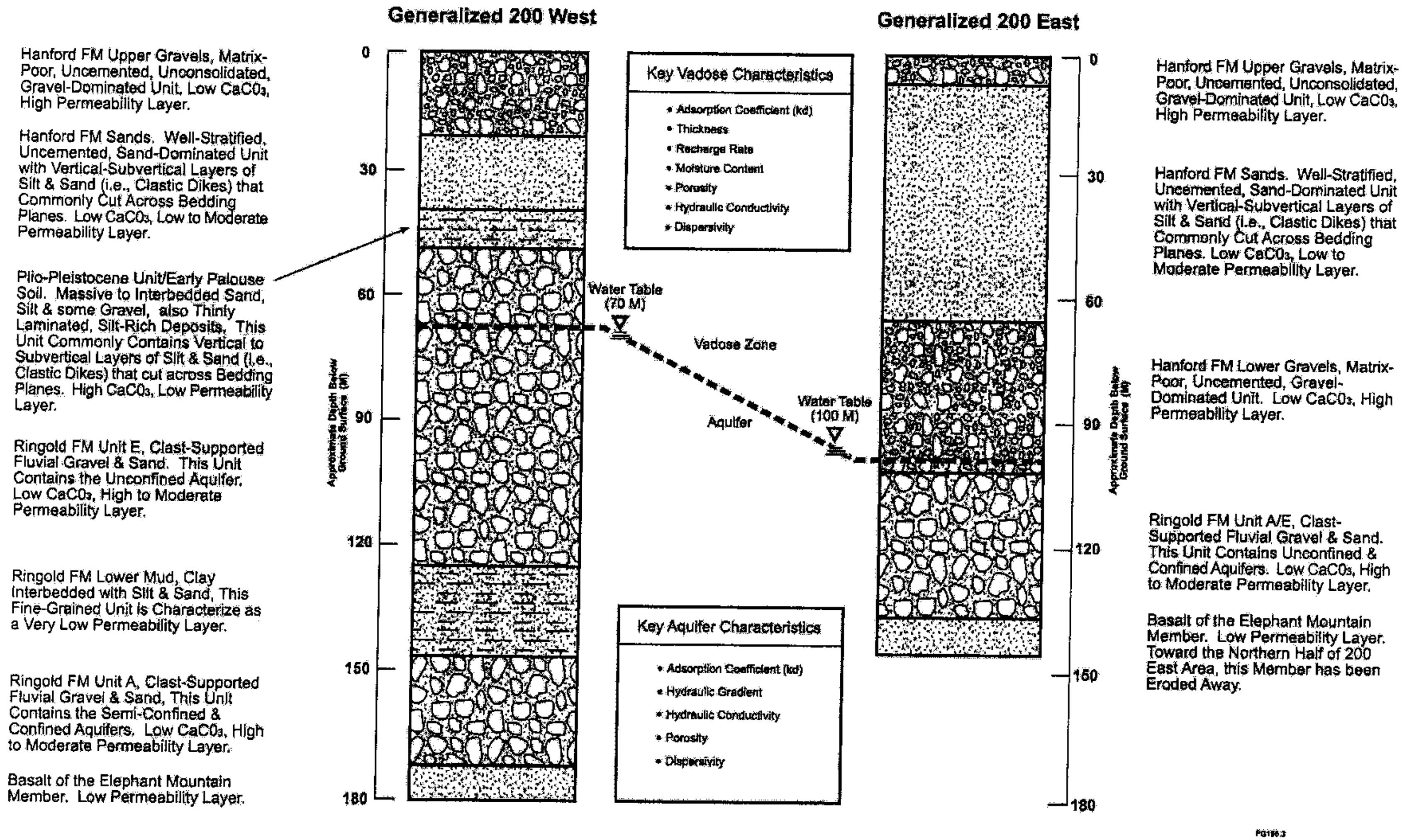

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Figure 2-14. General Conceptual Exposure Model.

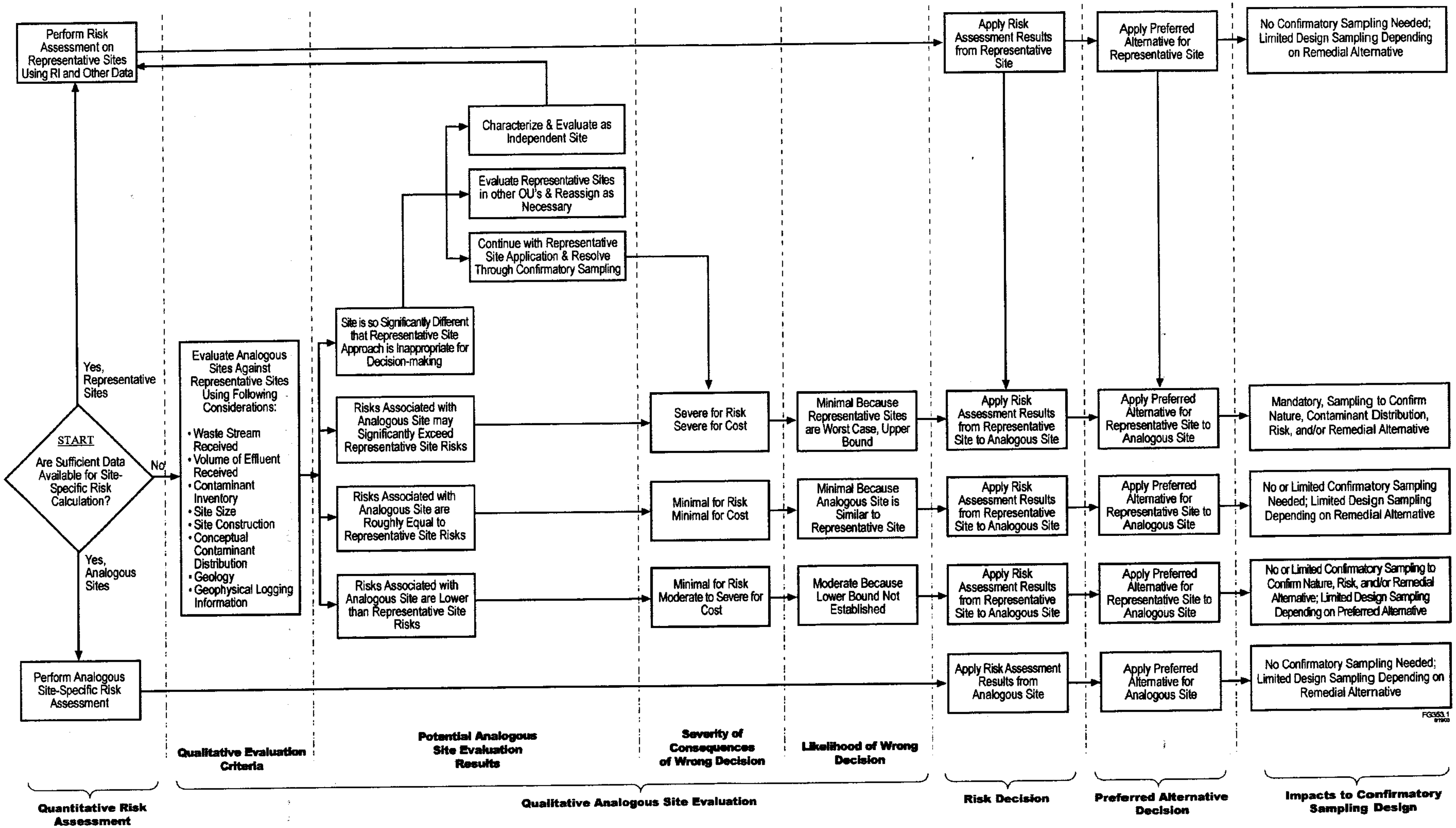

Figure 2-15. Conceptual Exposure Model.

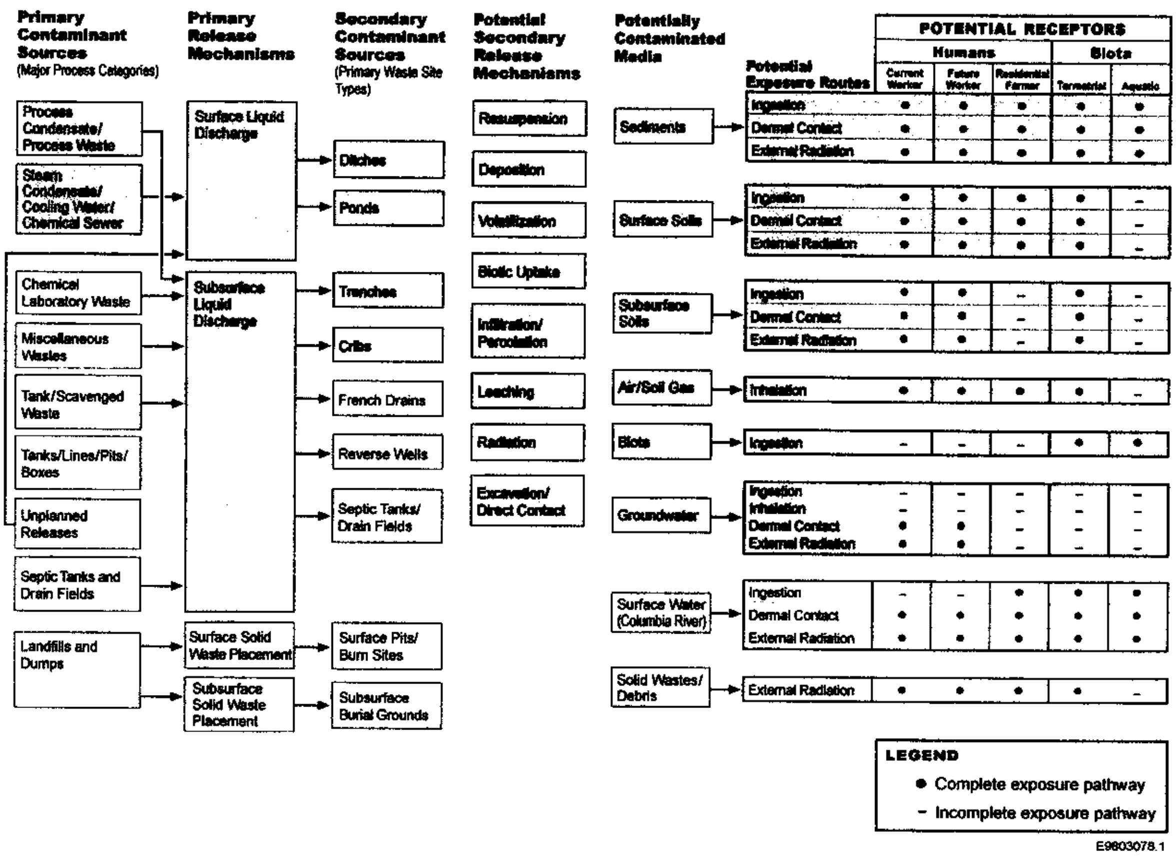

Table 2-1. Lithofacies of the Cold Creek Unit.

Lithofacies	Environment of Deposition	Previous Site Nomenclature
Fine-grained, laminated to massive. Consists of a brown- to yellow very well sorted cohesive, compact, and massive- to laminated- and stratified-fine-grained sand and silt. It is moderately to strongly calcareous with relatively high natural background gamma activity.	Fluvial-overbank and eolian	Palouse soil, early "Palouse" soil, Hanford formation/ Plio-Pleistocene unit silt.
Fine- to coarse-grained, calcium carbonate cemented. Consists of basaltic to quartzite gravels, sands, silts, and clay that are cemented with one or more layers of secondary, pedogenic calcium carbonate.	Calcic paleosol	Highly weathered subunit of the Plio-Pleistocene unit/ caliche, calcrete.
Coarse-grained, multilithic. Consists of rounded, quartzose to gneissic clast-supported pebble- to cobble-size gravel with a quartzo-feldspathic sand matrix.	Mainstream alluvium	Distantly derived subunit of the Plio-Pleistocene unit/ pre-Missoula flood gravel.
Coarse-grained, angular, basaltic. Consists of angular, clast- to matrix-supported basaltic gravel in a poorly sorted mixture of sand and silt with no stratification. Calcic paleosols may be present.	Colluvium	New facies designation for the Pasco Basin.
Coarse-grained, round basaltic lithofacies.	Sidestream alluvium	Locally derived subunit of the Plio-Pleistocene unit.

NOTE: Based on DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin.*

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1,2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
Representative Site												
216-U-10 Pond	The 216-U-10 Pond is an unlined topographic depression. It was 12 ha (30 a) with varying depth and was in operation from 1944 to 1985, when it was backfilled and surface stabilized.	The pond received from the following: 284-W Powerhouse, 231-Z Laboratory, 234-5Z Building, 2723-W Building, 2724-W Building, 221-U Building, 224-U Building, 241-U-110 Condenser Tank, and 242-S Evaporator Facilities via the 216-U-14 Ditch.	1.88	8,000	0.5	11	11	--	--	165,000,000	1,800,000 Effluent volume to pore volume ratio=92:1	Characterization is described in DOE/RL-2003-11. Contaminant Distribution Contaminants were detected beneath the 216-U-10 Pond to a maximum depth of about 42.6 m (140 ft). Maximum contaminant concentrations generally are present near the surface in the upper 2.0 m (6.5 ft) of the soil column. The depth to the bottom of the pond was about 2.0 m (6.5 ft) when it was actively receiving effluent. Soils above 2.0 m (6.5 ft) are characterized by material used to fill in the pond during decommissioning efforts, sediment from the bottom of the pond, or both. Cesium-137, Sr-90, Se-79, plutonium, and uranium are the predominant radionuclides detected from the surface to the bottom of the pond with concentrations generally decreasing with depth beneath the pond bottom. With few exceptions, radionuclides either were not detected or were detected at concentrations of less than about 2.0 pCi/g at depths greater than 2.0 m (6.5 ft). Maximum values of Tc-99 (4.6 pCi/g), Sr-90 (28 pCi/g), U-235 (2.4 pCi/g), and U-234 (56 pCi/g) sporadically are present at depths greater than 2.0 m (6.5 ft) bgs. In boreholes adjacent to the pond, Cs-137 and U-235 were detected above screening levels with Cs-137 (4.3 pCi/g) at approximately 0.8 m (2.5 ft) bgs and U-235 (5 pCi/g), detected 73 m (240 ft) bgs (reference: DOE/RL-2003-11). Maximum uranium: 56 pCi/g. Maximum Cs-137: 440 pCi/g. Maximum Sr-90: 28 pCi/g. Within the pond, Cs-137 was detected at 440 pCi/g decayed to 366 pCi/g (in 2002) 0 to 3 m (0 to 10 ft) bgs. Soil samples indicate that the average concentration of Cs-137 is 337 pCi/g. Comparison of the two data sets indicates good correlation between the logging and laboratory data. From a groundwater contamination perspective, the effluent volume discharged to the 216-U-10 Pond was greater than the soil column pore volume, suggesting the volume released was sufficient to reach the aquifer during waste site operations. PNNL-13788 indicates that mobile contaminants (nitrate, carbon tetrachloride, and uranium) exceed groundwater protection standards near the pond. Nitrate and uranium may be associated with waste disposal practices at the pond as well as at other waste sites in the 200 West Area. The results of 216-U-10 Pond modeling indicate that Se-79, Tc-99, cyanide, fluoride, and the uranium species reach the groundwater at significant concentrations.
Analogous waste sites to be evaluated by the 216-U-10 Pond model												
216-S-16P Pond	The 216-S-16P Pond consists of four lobes separated by dikes and a leach trench. Lobe #4 never was used. In 1975, the pond was backfilled and surface stabilized using soil from the dikes. The pond was 125,000 m^2 (1,350,000 ft^2) and 0.9 m (3 ft) deep.	The pond received process cooling water and steam from the 202-S Building (only Lobe #1 received 202-S waste). In 1973, the 216-U-9 Ditch was connected to the 216-S-16 Ditch to divert overflow from the 216-U-10 Pond to the 216-S-16 Pond. The pond was opened in 1957 and operated until 1975.	3120 More than rep site	368 Less than rep site	--	30 More than rep site	45.1 More than rep site	--	--	40,700,000 Less than rep site	2,258,146 Equivalent to rep site Effluent volume to pore volume ratio=18:1	The 216-S-16P Pond is analogous to the 216-U-10 Pond as indicated by process history, contaminant inventory, and effluent volume received, and is analogous because of the following. 1. Construction and configuration are similar (unlined ponds). 2. Waste was received from the same type of source (202-S Building), although the volume received was less. 3. The inventory for this site is very similar to and bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. The highest concentration for Cs-137 was 391 pCi/g and the Am-241 concentration was 19.7 pCi/g at 1.1 m (3.5 ft bgs) (1976). 6. The effluent volume discharged to this crib is 18 times the soil column capacity, bounded by the 216-U-10 Pond, and suggests a potential for groundwater impact.
216-S-17 Pond	The 216-S-17 Pond was formed by earthen dikes, approximately 1 m (3.3 ft) high on the north and west side of the site. Overall site dimensions are 292 by 292 m (958 by 958 ft), or 6.9 to 8.5 ha (17 to 21 a) and 3.1 m (10 ft) deep. The pond was in operation from 1951 to 1954.	The pond received process effluent from the 202-S Building and overflow from the 216-U-10 Pond via the 216-U-9 Ditch.	134 More than rep site	3 Less than rep site	--	12.7 More than rep site	15.9 More than rep site	--	140 More than rep site	6,440,000 More than rep site	1,529,712 Equivalent to rep site Effluent volume to pore volume ratio=4:1	The 216-S-17 Pond is analogous to the 216-U-10 Pond as indicated by process history, contaminant inventory, and effluent volume received, and is analogous because of the following. 1. Construction and configuration are similar (unlined ponds). 2. Waste was received from the same source (e.g., 202-S Building) and overflow from the 216-U-10 Pond, although the volume received was significantly less. 3. The contaminant inventory for this site is appropriate given its source (overflow from the 216-U-10 Pond). 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is bounded by the 216-U-10 Pond and is four times the soil column capacity, suggesting a potential for groundwater impact.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
216-T-4A Pond	The 216-T-4A Pond is a natural surface depression, 6.5 ha (16 a) in area, and 3.1 m (10 ft) deep. In 1972, the bottom of the original pond was scraped to a depth of 15 to 23 cm (6 to 9 inches) and the scrapings were placed in the 218-W-2A Burial Ground (Trench #27). The scraped area was covered with clean soil in 1973. The pond was "L" shaped. Land from the site is now the 218-W-2A Burial Grounds.	The pond received 221-T Building and 224-T Building process cooling water, 221-T Building steam condensate, 242-T Evaporator condenser cooling water and steam condensate, 2706-T Building decontamination waste, and 242-T Condenser cooling water. The pond was in operation from 1944 to 1972. According to WIDS, the contaminant inventory for the 216-T-4A and 216-T-4B Ponds are reported together.	--	--	--	--	--	--	--	42,500,000 Less than rep site	13,668 Less than rep site Effluent volume to pore volume ratio=3100:1 (greater than rep site)	The 216-T-4A Pond is analogous to the 216-U-10 Pond as indicated by construction, process history, contaminant inventory, effluent volume received, and vertical extent of contamination, and is analogous because of the following. 1. Construction and configuration are similar (unlined ponds). 2. Waste was received from a similar source (e.g., process condensate from 221-T, 224-T, and 242-T Buildings), although the volume received was less. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond and is similar, as compared to the volume received and source. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is more than 3,000 times the soil column capacity and suggests a high potential for groundwater impact.
216-T-4B Pond	The 216-T-4B Pond replaced the 216-T-4A Pond. It was a natural depression that received runoff from the 216-T-4-2 Ditch. Normally, the volume of water in the new 216-T-4-2 Ditch was not enough to fill the pond because it usually was absorbed in the first quarter of the ditch, leaving the pond area dry. The pond is 0.5 m (1.5 ft) deep and 0.6 ha (1.5 a). A 397 m (1,300-ft) long, 6.1 m (12-ft) tall dike was built along the pond to keep the pond out of the 216-W-24 Burial Ground.	The pond received 242-T Evaporator steam condensate and condenser cooling water, and nonradioactive wastewater from 221-T Building air conditioning filter units and floor drains from 1972 to 1977. According to WIDS, the contaminant inventory for the 216-T-4A and 216-T-4B Ponds are reported together.	690 More than rep site	3.71 Less than rep site	--	6.23 Less than rep site	3.37 Less than rep site	--	--	--	--	The 216-T-4B Pond replaced the 216-T-4A Pond, is analogous to the 216-U-10 Pond as indicated by construction, process history, contaminant inventory, effluent volume received, and vertical extent of contamination, and is analogous because of the following. 1. Construction and configuration are similar (unlined ponds). 2. Waste was received from a similar source (e.g., process condensate from 221-T and 242-T Buildings), although the volume received was less. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The potential for groundwater impact is bounded by the 216-U-10 Pond.
216-U-9 Ditch	The 216-U-9 Ditch is an unlined ditch that was backfilled in 1954. A portion of the ditch was reopened in 1973 and used until 1975. It is 1,067 by 1.8 m (3,500 by 6 ft) and 1.5 m (5 ft) deep.	The ditch received overflow from the 216-U-10 Pond and connects the 216-U-10 Pond with the 216-S-17 Pond.	--	--	--	--	--	--	--	--	--	The 216-U-9 Ditch is analogous to the 216-U-10 Pond as indicated by source of the waste received and is analogous because of the following. 1. Construction is similar (unlined) but waste configuration is dissimilar (216-U-9 is a ditch whereas 216-U-10 is a pond). 2. The waste site received overflow from the 216-U-10 Pond. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this ditch and contaminant distribution are unknown; however, characterization test holes dug to 2.7 m (9 ft) and trenches dug to 1.2 m (4 ft) across the ditch revealed that no contamination was present; therefore, potential for groundwater impact is low.
216-U-11 Ditch	The 216-U-11 Ditch is an unlined ditch that was backfilled and surface stabilized in 1985 in conjunction with the 216-U-10 Pond. It is 1,375 by 1.2 m (4,510 ft by 4 ft) and 0.9 m (3 ft) deep. A flood plain in the southern portion of the ditch sometimes filled with contaminated water when significant amounts of water overflowed from the 216-U-10 Pond (reference: WIDS).	The ditch received waste overflow from the 216-U-10 Pond. The ditch operated from 1944 to 1957. The older portion was retired in 1955 with the remainder retired in 1957.	--	--	--	--	--	--	--	--	--	The 216-U-11 Ditch is analogous to the 216-U-10 Pond as indicated by source of waste received and is analogous because of the following. 1. Construction is similar (unlined) but waste configuration is dissimilar (216-U-11 is a ditch whereas 216-U-10 is a pond). 2. The 216-U-11 Ditch received overflow from the 216-U-10 Pond. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. Groundwater impact is bounded by the 216-U-10 Pond. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07).

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
216-S-5 Crib	The 216-S-5 Crib is a gravel-filled (approximately 12.2 m^3 [16 yards]) crib with two lengths of perforated, corrugated metal pipe that form a cross. A hole was cut along the top edge of the crib to discharge overflow to a nearby trench. Overflow was 5% of the total flow. When the REDOX Plant A-2 dissolver and H-4 coils failed, the dose rates at the overflow area reached 17 rad/h. The crib has been surface stabilized. The crib was in operation from 1954 to 1957 and is 64 by 64 m (210 by 210 ft) and 3.1 m (10 ft) deep.	The crib received REDOX Plant effluent with a low potential for contamination and process vessel cooling water and steam condensate water from the 202-S Building. The 216-S-5 Crib replaced the 216-S-17 Crib to handle lower activity waste (the 216-S-6 Crib was designed to handle higher activity waste to replace the 216-S-17 Crib).	271 More than rep site	580 Less than rep site	--	26.4 More than rep site	54.1 More than rep site	--	100 More than rep site	4,100,000 Less than rep site	73,746 Less than rep site Effluent volume to pore volume ratio=55:1 (less than rep site)	The 216-S-5 Crib is analogous to the 216-U-10 Pond as indicated by process history, contaminant inventory, and effluent volume received, and is analogous because of the following. 1. Construction and waste site configuration of the 216-S-5 Crib (gravel-filled crib with PVC distribution lines) and 216-U-10 Pond (unlined ditch) are dissimilar in construction but similar in that they both are unlined. 2. Waste was received from the same source (e.g., process effluent from the 202-S Building and overflow from the 216-U-10 Pond), although the volume received was significantly less. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is more than 50 times the soil column capacity along with more than 270 kg of uranium, suggesting a high potential for groundwater impact; however, borehole 299-W26-06 (A5445) indicated no Cs-137 contamination to 63.7 m (209 ft).
216-S-6 Crib	The 216-S-6 Crib is a square pit filled with gravel with perforated pipe running down the center, and six pipes branching off perpendicular to the main pipe. The northwest end of the crib is heavily populated with growing tumbleweeds, but no contamination was found. The crib was in operation from 1954 to 1977 and is 64 by 64 m (210 by 210 ft) and 4.6 m (15 ft) deep.	The crib received process cooling water and steam condensate from the 202-S Building waste and REDOX Plant effluent with a high potential for contamination. High potential activity waste was sent to the 216-S-6 Crib; the lower activity waste to the 216-S-5 Crib. The 216-S-6 Crib was designed to handle higher activity waste to replace the 216-S-17 Crib.	271 More than rep site	473 Less than rep site	--	115 More than rep site	204 More than rep site	--	140 More than rep site	4,470,000 Less than rep site	35,117 Less than rep site Effluent volume to pore volume ratio=127:1 (greater than rep site)	The 216-S-6 Crib is analogous to the 216-U-10 Pond as indicated by process history, contaminant inventory, and effluent volume received, and is analogous because of the following. 1. Construction and waste site configuration of the 216-S-5 Crib (gravel-filled crib with PVC distribution lines) and 216-U-10 Pond (unlined ditch) are dissimilar in construction but similar in that they both are unlined. 2. Waste was received from the same source (e.g., process effluent from the 202-S Building and overflow from the 216-U-10 Pond), although the volume received was significantly less. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is more than 100 times the soil column capacity along with more than 270 kg of uranium, suggesting a high potential for groundwater impact.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
216-A-6 Crib	The 216-A-6 Crib was constructed with a vitrified clay pipe placed horizontally over the length of the unit. Five lengths of perforated pipe are perpendicular to the first pipe. The pipes are covered with approximately 2580 m^3 (3,370 yards) of gravel. Periodically, the crib exceeded flow capacity and contaminated the ground surface (UPR-200-E-21, UPR-200-E-29). A trench was dug connecting the crib with the 216-A-29 Ditch to collect the overflow water. UPR-200-E-19 occurred when low-level fission product seeped into the ground around the edges of the concrete pad at the 216-A-6 Proportional Sampler Pit. The release was caused by moisture dripping from the vent pipe bonnet. The crib is 31 by 31 m (100 by 100 ft) and 6.4 m (21 ft) deep, and was in operation from 1955 to 1970.	The crib received steam condensate, equipment disposal tunnel floor drainage, water-filled door drainage, and slug storage basin overflow waste from the 202-A Building. The 216-A-6 Crib was used in conjunction with the 216-A-30 Crib.	164 More than rep site	35.6 Less than rep site	--	105 More than rep site	44.1 More than rep site	--	10,000 More than rep site	3,400,102 Less than rep site	23,024 Less than rep site Effluent volume to pore volume ratio=148:1 (greater than rep site)	The 216-A-6 Crib is analogous to the 216-U-10 Pond as indicated by similar process history and contaminant inventory (although the 216-U-10 Pond is located in the southwest portion of the 200 West Area and the 216-A-6 Crib is located in the southeast portion of the 200 East Area) and is analogous because of the following. 1. Construction and waste site configuration of the 216-S-5 Crib (gravel-filled crib with PVC distribution lines) and 216-U-10 Pond (unlined ditch) are dissimilar in construction but similar in that they both are unlined. 2. Waste was received from a similar source (e.g., floor drain and steam condensate), although the volume received was significantly less due to site configuration differences. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is more than 140 times the soil column capacity along with more than 160 kg of uranium, suggesting a high potential for groundwater impact.
216-A-30 Crib	The 216-A-30 Crib is a gravel-filled (approximately 9170 m^3 [12,300 yards]) crib that has been isolated and backfilled. There are two distribution pipes, 38 cm (15 in. diameter). One pipe extends half the length of the crib (214 m [700 ft]) and one extends the full length of the crib (427 m [1,400 ft]). During the winter of 1971 and early 1972, an alkaline deposit formed over the surface of the 216-A-30 Crib. Exploration into the crib revealed a salt deposit that condensed from vapors emitted through the soil. The ground then was covered with layers of sand and plastic. The crib is 427 by 3.1 m (1,400 by 10 ft) and 3.7 m (12 ft) deep, and was in operation from 1955 to 1970.	The crib received steam condensate, equipment disposal tunnel floor and water-filled door drainage, and the slug storage basin overflow waste from the 202-A Building and PUREX Facility steam condensate. The 216-A-30 Crib was used in conjunction with the 216-A-6 Crib.	297 More than rep site	73.1 Less than rep site	0.198 Less than rep site	117 More than rep site	102 More than rep site	--	16,000 More than rep site	7,110,213 Less than rep site	31,758 Less than rep site Effluent volume to pore volume ratio=224:1 (greater than rep site)	The 216-A-30 Crib is analogous to the 216-U-10 Pond as indicated by similar process history and contaminant inventory (although the 216-U-10 pond is located in the southwest portion of the 200 West Area and the 216-A-30 Crib is located in the southeast portion of the 200 East Area), and is analogous because of the following. 1. Construction and waste site configuration of the 216-S-5 Crib (gravel-filled crib with PVC distribution lines) and 216-U-10 Pond (unlined ditch) are dissimilar in construction but similar in that they both are unlined. 2. Waste was received from a similar source (e.g., floor drain and steam condensate), although the volume received was significantly less due to site configuration differences. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is more than 200 times the soil column capacity along with more than 290 kg of uranium, suggesting a high potential for groundwater impact.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1,2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
216-S-25 Crib	The 216-S-25 Crib is a gravel-filled site (31,300 m [41,000 yards]) with a below-grade distribution pipe. Growing tumbleweeds were contaminated at levels from 12,000 to 36,000 d/min. Soil was contaminated from 1,000 to 4,000 d/min. The crib is 175 by 3.01 m (575 by 10 ft) and 3.1 m (10 ft) deep, and was in operation from 1973 to 1992.	The crib received 242-S Evaporator process steam condensate and 216-U-1 Crib and 216-U-2 Crib groundwater pump-and-treat effluent. In 1976, a scintillation detector was inserted into one of the wells associated with the 216-S-25 Crib (TW-299-W-23-9, -11, and -12) with no measurable dose rate.	167 More than rep site	0.047 Less than rep site	--	0.065 Less than rep site	0.041 Less than rep site	--	--	288,000 Less than rep site	9,615 Less than rep site Effluent volume to pore volume ratio=24:1 (less than rep site)	The 216-S-25 Crib is analogous to the 216-U-10 Pond based on the type of waste liquid received and the low specific activity received (contaminated groundwater from a pump-and-treat effort), and is analogous because of the following. 1. Construction and waste site configuration of the 216-S-5 Crib (gravel-filled crib with PVC distribution lines) and 216-U-10 Pond (unlined ditch) are dissimilar in construction but similar in that they both are unlined. 2. Waste was received from groundwater, although the volume received was significantly less than the 216-U-10 Pond due to site configuration differences. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is 24 times the soil column capacity along with more than 160 kg of uranium, suggesting a potential for groundwater impact.
216-A-37-2 Crib	The 216-A-37-2 Crib was built as a replacement for the 216-A-30 Crib. There are two associated steel drain pipes. One is perforated and runs the length of the unit. The other is not perforated and runs from west to east only to the center of the unit, 1.5 m (5 ft) above the bottom. The crib is 427 by 3.1 m (1,400 by 10 ft) and 3.4 m (11 ft) deep, and was in operation from 1983 to 1995.	The crib received PUREX Facility steam condensate waste in parallel operations with the 216-A-30 Crib. Monitoring Wells 299-ES-21-21 through -24 extend to 90 m (295 ft) and support the 216-A-37-2 Crib.	51.1 More than rep site	--	0.099 Less than rep site	0.2 Less than rep site	0.3 Less than rep site	--	--	1,090,033 Less than rep site	30,569 Less than rep site Effluent volume to pore volume ratio=35:1 (less than rep site)	The 216-A-37-2 Crib is analogous to the 216-U-10 Pond as indicated by similar process history and contaminant inventory (although the 216-U-10 Pond is located in the southwest portion of the 200 West Area and the 216-A-37-2 Crib is located in the southeast portion of the 200 East Area), and is analogous because of the following. 1. Construction and waste site configuration of the 216-S-5 Crib (gravel-filled crib with PVC distribution lines) and 216-U-10 Pond (unlined ditch) are dissimilar in construction but similar in that they both are unlined. 2. Waste was received from a similar source (e.g., floor drain and steam condensate), although the volume received was significantly less due to site configuration differences. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond and appropriate given its source (overflow from the 216-U-10 Pond). 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is more than 30 times the soil column capacity, suggesting a potential for groundwater impact.
216-B-55 Crib	The 216-B-55 Crib is filled with gravel (approximately 1376 m^2 [1,800 ft^2]) and contains a perforated pipe that runs the length of the unit. The site had two gauge wells of 20 cm (8-in.) steel pipe with a galvanized sheet metal cap. The crib is 229 by 3.1 m (750 by 10 ft) and 3.4 m (11 ft) deep, and was in operation from 1967 to 1991.	The crib received steam condensate from the 221-B Building.	6.71 More than rep site	0.65 Less than rep site	3.6×10^{-6} Less than rep site	13.7 Similar to rep site	7.23 Less than rep site	--	--	1,230,000 Less than rep site	18,220 Less than rep site Effluent volume to pore volume ratio=68:1 (less than rep site)	The 216-B-55 Crib is analogous to the 216-U-10 Pond based on similarities in source of waste received (steam condensate) and is analogous because of the following. 1. Construction and waste site configuration of the 216-S-5 Crib (gravel-filled crib with PVC distribution lines) and 216-U-10 Pond (unlined ditch) are dissimilar in construction but similar in that they both are unlined. 2. Waste was received from a similar source. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond and similar, given the volumes of waste received (216-U-10 Pond received more than 100 times the waste volume). 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged to this crib is approximately 68 times the soil column capacity, suggesting a potential for groundwater impact; however, well 299-E28-12, which monitors the 216-B-55 Crib, indicates a breakthrough to groundwater has not occurred.
216-S-172 Control Structure	The 216-S-172 Control Structure is an underground concrete structure with interior sluice gates. It is 4.1 by 2.2 by 2.1 m deep (13 by 7 by 7 ft) with 25.4 cm (10 in.) thick walls.	The structure received process cooling waste and steam condensate from the 202-S Building and sent it to the 216-S-16D Ditch. The structure has been covered with soil and posted with URM/Cave-in Potential signs. It operated from 1956 to 1976.	--	--	--	--	--	--	--	--	--	The 216-S-172 Control Structure is analogous to the 216-U-10 Pond as indicated by process history and is analogous because of the following. 1. Construction of the 216-S-172 Control Structure is dissimilar to the 216-U-10 Pond (concrete structure vs. unlined pond). 2. Waste was received from the same source (e.g., 202-S Building) as the 216-S-16 Ditch and 216-S-17 Pond. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond and is reflective of the 216-S-16 Ditch and 216-S-17 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. Groundwater impact is bounded by the 216-U-10 Pond. The construction of the structure (concrete control box) and no indication of leakage indicate that impact is minimal.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
2904-S-160 Control Structure	The 2904-S-160 Control Structure is a below-grade "pentagon" structure with reinforced concrete walls, floor, and roof with 60 cm (2 ft) diameter vitrified clay inlet and outlet piping. It is a 3 m (10-ft) pentagon, 2.74 m (9 ft) deep with 30.5 cm (1 ft) thick walls.	It received process cooling and steam condensate from the 202-S Building to the 216-S-17 Pond, 216-S-6 Crib, and 216-S-16 Pond. It operated from 1954 to 1976.	--	--	--	--	--	--	--	--	--	The 216-S-160 Control Structure is analogous to the 216-U-10 Pond as indicated by process history and is analogous because of the following. 1. Construction of the 216-S-172 Control Structure is dissimilar to the 216-U-10 Pond (concrete structure vs. unlined pond). 2. Waste was received from the same source (e.g., 202-S Building) as the 216-S-17 Pond, 216-S-6 Crib, and 216-S-16 Pond. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond and is reflective of the 216-S-17 Pond, 216-S-6 Crib, and 216-S-16 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged is bounded by the 216-U-10 Pond and suggests a negligible potential for groundwater impact. There are low levels of contamination inside the structure (300 c/min loose surface contamination) and in the surrounding soil (500 c/min).
2904-S-170 Control Structure	The 2904-S-170 Control Structure is a below-grade structure with reinforced concrete walls, floor, and roof with 76 cm (2.5 ft) diameter vitrified clay inlet and outlet piping. The 2904-SA Sample Building is located over the south end of the weir structure. It is 4.9 by 1.5 m (16 by 5 ft) with 25.4 cm (10 in.) thick walls.	The 2904-S-170 Control Structure directed waste from the 202-S REDOX Facility to the 2904-SA Sample Building from 1954 to 1976.	--	--	--	--	--	--	--	--	--	The 216-S-170 Control Structure is analogous to the 216-U-10 Pond as indicated by process history and is analogous because of the following. 1. Construction of the 216-S-172 Control Structure is dissimilar to the 216-U-10 Pond (concrete structure vs. unlined pond). 2. Waste was received from the same source (e.g., 202-S Facility) as the 216-S-17 Pond, 216-S-6 Crib, and 216-S-16 Pond. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond and is reflective of the 216-S-17 Pond, 216-S-6 Crib, and 216-S-16 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. Groundwater impact is bounded by the 216-U-10 Pond. The construction of the structure (concrete control box) and no indication of leakage indicate that impact is minimal.
2904-S-171 Control Structure	The 2904-S-171 Control Structure is a below-grade rectangular structure with reinforced concrete walls, floor, and roof with 46 cm (1.5 ft) diameter vitrified clay inlet and outlet piping and hand-operated gate valve. The site has been backfilled with clean material. It is 4 by 2.6 m (13 by 9 ft) and 3.05 m (10 ft) deep with 25.4 cm (10 in.) thick walls.	The 2904-S-171 Control Structure was used to measure and regulate the flow of process waste that was being routed to the 216-S-6 Crib and was in service from 1954 to 1976.	--	--	--	--	--	--	--	--	--	The 2904-S-171 Control Structure is analogous to the 216-U-10 Pond as indicated by process history. The site is analogous to the 216-U-10 Pond because of the following. 1. Construction of the 216-S-172 Control Structure is dissimilar to the 216-U-10 Pond (concrete structure vs. unlined pond). 2. Waste was received from the same source (e.g., 202-S Facility) as the 216-S-6 Crib. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond and is reflective of the 216-S-6 Crib. 4. The geology of both sites is similar. 5. The extent of contamination spread is expected to be similar. 6. Groundwater impact is bounded by the 216-U-10 Pond. The construction of the structure (concrete control box) and no indication of leakage indicate that impact is minimal.
207-S Retention Basin	The 207-S Retention Basin is a concrete structure, backfilled with soil, with an overflow tank located in the center of the north end and an outlet weir structure adjacent to the south wall. The retention basin is 40 by 40 m (130 by 130 ft) and 2.1 m (6.75 ft) deep with 25.4 cm (10 in.) thick walls.	The site received process cooling water and steam from the 202-S Building, en route to the 216-S-17 Pond and 216-S-16 Pond. It was in operation from 1951 to 1954.	--	--	--	--	--	--	--	--	--	The 207-S Retention Basin is analogous to the 216-U-10 Pond as indicated by process history and is analogous because of the following. 1. Construction of the 217-S Retention basin is dissimilar to the 216-U-10 Pond (concrete structure vs. unlined pond). 2. The 207-S Retention Basin was an intermediate stop for waste transferred from the 202-S Building to the 216-S-17 Pond and/or 216-S-16 Pond, which are analogous to the 216-U-10 Pond. Waste was received from the same source (e.g., 202-S Building) as the 216-S-16P and -17 Ponds. 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond and is reflective of the 216-S-16P and -17 Ponds. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond, although there is no documented evidence that the basin has leaked, indicating minimal contamination spread. 6. Groundwater samples taken on July 31, 1964 (W-22-13 and W-22-14) indicate the presence of Sr-90 groundwater contamination; however, there is no evidence that the groundwater contamination resulted from the 207-S Retention basin.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2] Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
216-B-64 Retention Basin	The 216-B-64 Retention Basin is an emergency diversion basin for steam condensate that exceeded crib release limits. The crib is 51 by 13 m (167 by 42 ft) and 4.6 m (15 ft) deep, and was operational from 1974 to 1997.	The unit has not been used except for an initial test. The source of effluent was planned to be diverted steam condensate from the 221-B Building. A radiological speck of contamination, present in the basin, migrated from the adjacent surface contamination (270-E-1 Neutralization Tank riser, named UPR-200-E-64 [alias UN-216-E-36]).	--	--	--	--	--	--	--	--	--	The basin was intended to receive 221-B Building waste that exceeded release limits. A facility test was conducted, but the basin never was used. The 216-B-64 Retention Basin is analogous to the 216-U-10 Pond based on the projected source of waste and is analogous because of the following. 1. Construction and waste site configuration of the 216-B-64 Retention Basin (concrete basin) are dissimilar to the 216-U-10 Pond (unlined pond). 2. Waste was planned to be received from a similar waste stream as compared to the 216-U-10 Pond. 3. The contaminant inventory for this site consists of loose surface contamination spread from UPR-200-E-64, which is different from the 216-U-10 Pond. 4. The geology of both sites is similar. 5. Documentation indicates no liquid leakage, because contaminated liquid never was introduced. 6. There is no impact to groundwater because only surface contamination is present (no contaminated liquid was introduced to the basin).
200-E-113 Process Sewer	The 200-E-113 Process Sewer is an underground, 0.406 m (16 in.) diameter steel pipeline that extends from the PUREX Plant to a distribution box located on the west side of the 216-A-6 Crib and continues eastward to the 216-A-30 Crib. The 216-A-42C Valve Box is located on the pipeline, inside a domed cover and was installed to select either the 216-A-30 Crib or the 216-A-6 Crib for discharge. The pipeline is 538 m (1,765 ft) long and is buried 2.4 m (8 ft) deep.	The process sewer transported steam condensate waste from the PUREX Facility to the 216-A-30 Crib or 216-A-6 Crib. Waste received is associated with the steel pipeline and adjacent contaminated soil from pipe leaks. This process sewer was in operation from 1961 to 1970. In 1995, the distribution box was filled with concrete, backfilled, and stabilized.	--	--	--	--	--	--	--	--	--	The 200-E-113 Process Sewer is analogous to the 216-U-10 Pond as indicated by similar process history and contaminant inventory (although the 216-U-10 Pond is located in the southwest portion of the 200 West Area and the 216-A-6 Crib is located in the southeast portion of the 200 East Area), and is analogous because of the following. 1. Construction and waste site configuration are dissimilar to the 216-U-10 Pond (unlined pond vs. steel pipeline). 2. Waste was transferred from a similar source via the 200-E-113 Process Sewer and contained a similar waste stream as compared to the 216-U-10 Pond. 3. The contaminant inventory for this site is included in the 216-A-6 and 216-A-30 Cribs inventory. 4. The geology of both sites is similar. 5. Documentation does not indicate that a pipeline leakage has occurred. 6. The effluent transferred via this process sewer is bounded by the 216-U-10 Pond, although, because the pipeline has not leaked, groundwater impact from the pipeline is not evident.
UPR-200-E-19	UPR-200-E-19 was caused when low-level fission product seeped into the ground around the edges of the concrete pad at the 216-A-6 Proportional Sampler Pit. The release was caused by moisture dripping from the vent pipe bonnet. The UPR occurred in 1959.	The source of the UPR was 216-A-6 Crib effluents due to a leaking valve bonnet at the proportional sampler pit.	--	--	--	--	--	--	--	--	--	UPR-200-E-19 is analogous to the 216-U-10 Pond because of its association with the 216-A-6 Crib and because of its location, and is analogous because of the following. 1. The UPR is similar to the 216-U-10 Pond because liquid spilled onto an unlined area. 2. Waste was received from the 216-A-6 Crib. 3. The contaminant inventory for this site is included in the inventory for the 216-A-6 Crib and is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. Contamination from the UPR is adjacent to the 216-A-6 Crib; therefore, the extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged (and groundwater impact) is included with the 216-A-6 Crib; therefore, it is bounded by the 216-U-10 Pond.
UPR-200-E-21	UPR-200-E-21 was caused when 216-A-6 Crib overflowed and contaminated the adjacent area to 500 mrad/h. The UPR occurred in 1959.	The source of the UPR was 216-A-6 Crib effluents. In 1981, 15.2 to 30.5 cm (6 to 12 in.) of soil were removed and disposed in the 216-A-4 Burial Grounds. The excavated area was covered with 46 to 61 cm (18 to 24 in.) of clean soil.	--	--	--	--	--	--	--	--	--	UPR-200-E-21 is analogous to the 216-U-10 Pond because of its association with the 216-A-6 Cribs and because of its location, and is analogous because of the following. 1. The UPR is similar to the 216-U-10 Pond because liquid spilled onto an unlined area. 2. Waste was received from the 216-A-6 Crib. 3. The contaminant inventory for this site is included in the inventory for the 216-A-6 Crib and is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. Contamination from the UPR is adjacent to the 216-A-6 Crib; therefore, the extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged (and groundwater impact) is included with the 216-A-6 Crib; therefore, it is bounded by the 216-U-10 Pond.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2] Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
UPR-200-E-29	UPR-200-E-29 was caused when the 216-A-6 Crib overflowed and contaminated the adjacent area to 30 rad/h at 1.2 m (4 ft). The UPR occurred in 1961.	The source of the UPR was 216-A-6 Crib effluents. After the UPR, the site was covered with 15 cm (6 in.) of sand and topped with plastic sheeting. In 1972, the site was covered with an additional 46 cm (18 in.) of sand and 10 cm (4 in.) of gravel. The crib was surface stabilized in 1993.	--	--	--	--	--	--	--	--	--	UPR-200-E-29 is analogous to the 216-U-10 Pond because of its association with the 216-A-6 Crib and because of its location, and is analogous because of the following. 1. The UPR is similar to the 216-U-10 Pond because liquid spilled onto an unlined area. 2. Waste was received from the 216-A-6 Crib. 3. The contaminant inventory for this site is included in the inventory for the 216-A-6 Crib and is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. Contamination from the UPR is adjacent to the 216-A-6 Crib; therefore, the extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged (and groundwater impact) is included with the 216-A-6 Crib; therefore, it is bounded by the 216-U-10 Pond.
UPR-200-W-124	UPR-200-W-124 occurred when a dike broke at the "REDOX Swamp" located southeast of the 200 West Area. The pond located southeast of the 200 West Area is 216-S-19; however, the dike break could have occurred at the 216-S-17 Pond. The UPR was 9 m (30 ft) wide and 305 m (1,000 ft) long. The location suggests this UPR is part of the 216-S-17 Pond's footprint and would be remediated with 216-S-17.	The source of this UPR was cooling water from 202-S Processing Facility tanks. This UPR occurred in 1959.	--	--	--	--	--	--	--	--	--	UPR-200-W-124 is analogous to the 216-U-10 Pond as indicated by process history and is analogous because of the following. 1. Construction and configuration are similar (216-U-10 is an unlined pond and UPR-W-114 is an unlined trench). 2. Waste was received from the same source (e.g., 202-S Building). 3. The contaminant inventory for this site is bounded by the 216-U-10 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-10 Pond. 6. The effluent volume discharged is bounded by the 216-U-10 Pond and suggests a minimal potential for groundwater impact. UPR 200-W-124 is located within the footprint of the 216-S-17 Pond.
Representative Site												
216-U-14 Ditch	The 216-U-14 Ditch is an unlined ditch, backfilled, and surface stabilized in sections with the last section completed in 1997. It is 1731 by 1.2 m (5,680 by 4 ft) (bottom width) and 3.1 m (10 ft) deep.	The ditch received waste from the following: 284-W Powerhouse; 2723-W Original Laundry Facility; 2724-W New Laundry Facility; 221-U, 224-U, 271-U, and 242-S Steam Evaporators; and 241-U-110 Condenser Tank.	--	--	--	--	--	--	--	1,220,000 (Reference: WIDS)	--	Characterization is described DOE/RL-2003-11. <u>Contaminant Distribution</u> Contamination associated with the 216-U-14 Ditch was detected from 2.7 to 5.8 m (9 to 19 ft) bgs. The major zone of contamination is from 2.7 to 3 m (9 to 10 ft) bgs, corresponding to the ditch bottom with maximum concentrations of Cs-137 (2228 pCi/g), plutonium (10 pCi/g), Am-241 (1.6 pCi/g), Co-60 (0.62 pCi/g), Tc-99 (12 pCi/g), Sb-125 (0.10 pCi/g), and uranium (350 pCi/g). From 3.0 to 5.8 m (10 to 19 ft), concentrations decrease with depth. Available data indicate maximum concentrations at 5.8 m (19 ft) are 8.3 pCi/g for Cs-137, 0.39 pCi/g for plutonium isotopes (0.39), 1.6 pCi/g for Am-241, and 7 pCi/g for uranium. Strontium-90 also was detected (between 0.81 pCi/g and 5.2 pCi/g) beneath the ditch. Maximum concentrations for Sr-90 typically were detected from 3.6 to 4.5 m (12 to 15 ft) bgs. Distribution of contaminants in the ditch also varies along its length. Maximum uranium: 350 pCi/g. Maximum plutonium: 10 pCi/g. Maximum Am-241: 1.6 pCi/g. Maximum Cs-137: 440 pCi/g. Maximum Sr-90: 28 pCi/g. Contaminants with large distribution coefficients (e.g., Cs-137 and plutonium) were detected in higher concentrations near the head end of the ditch. Contaminants with moderate to low contaminant distribution coefficients (e.g., Sr-90, uranium) were detected in higher concentrations at the lower end of the ditch. Antimony was the only metal detected above screening levels (detected at 3.4 to 5.8 m (11 to 19 ft) bgs with concentrations from 6.1 and 7.0 mg/kg. Very little radiological contamination was detected adjacent to the 216-U-14 Ditch. According to Section 3.2.4.3 of DOE/RL-2003-11, the effluent volume discharged to the 216-U-14 Ditch is greater than the soil column pore volume, suggesting that the volume of effluent released was sufficient to reach the aquifer during waste site operation. Impact to groundwater also was confirmed in WHC-EP-0698 by comparing discharge data, changes in water table elevation, and groundwater chemistry over time. PNNL-13788 indicates that mobile contaminants (carbon tetrachloride and uranium) exceed groundwater protection standards near the ditch. Uranium from the 216-U-14 Ditch is known to be a source of groundwater contamination. The results of the 216-U-14 Ditch modeling indicate Tc-99, sulfide, and uranium reach the groundwater in appreciable concentrations.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1,2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
Analogous waste sites to be evaluated by the 216-U-14 Ditch model												
216-S-16D Ditch	The 216-S-16D Ditch connected the 202-S Building to the 216-S-16 Pond. The ditch is 518 by 1.2 m (1,700 by 4 ft) and 0.9 m (3 ft) deep.	The ditch connected the 202-S Building to the 216-S-16 Pond. In 1973, a portion of the 216-U-9 Ditch to the 216-S-16 Ditch to divert overflow from the 216-U-10 Pond to the 216-U-16 Pond. It is backfilled and surface stabilized. It operated from 1957 to 1975. Contaminant inventory is included in the 216-S-16 Pond inventory.	--	--	--	--	--	--	--	400,000 Less than rep site	20,067 Effluent volume to pore volume ratio=20:1	The 216-S-16D Ditch is analogous to the 216-U-14 Ditch as indicated by process history and is analogous because of the following. 1. The ditches are similar in construction and configuration (unlined ditches). 2. The ditch connected the 202-S Building to the 216-S-16 Pond, which is functionally similar to the 216-U-14 Ditch, and the waste was received from a similar source (e.g., 242-S Facility). 3. The contaminant inventory for this site is bounded by the 216-U-14 Ditch and is reflective of the 216-S-16 Pond. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch. 6. The effluent volume discharged as compared to the soil pore volume suggests a potential for groundwater impact. From a groundwater perspective, remedial investigations at other OU waste sites suggest infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07).
216-T-1 Ditch	The 216-T-1 Ditch is an earthen ditch with 2.5:1 slope and a 5 cm (2 in.) diameter vitrified clay feeder pipe. The ditch is 556 m (1,825 ft) long, 0.9 m (3 ft) wide, and 3.1 m (10 ft) deep. It was surface stabilized in 1995 when the 221-T Building inlet waste stream was rerouted to TEDF.	The ditch received miscellaneous waste from pilot experiments, decontamination waste, other waste from the 221-T Building, 271-T blowdown vessel cooling water, 221-T Building condensate from steam-heated radiators, and sodium hydroxide wash water (nonradioactive). It was in operation from 1944 to 1995.	5.94	0.1	--	0.04	0.04	--	--	178,000 Less than rep site	37,712 Effluent volume to pore volume ratio=4.7:1	The 216-T-1 Ditch is analogous to the 216-U-14 Ditch as indicated by construction and process history. The site is analogous to the 216-U-14 Ditch because of the following. 1. Construction and site configuration of the 216-T-1 Ditch are similar (unlined ditch). 2. The ditch connected the 221-T and 271-T Buildings to the 216-T-4A Pond and later the 216-T-4B Pond, similar to the 216-U-14 Ditch connection to the 216-U-10 Pond. Waste was received from a similar source (e.g., 221-T Building). 3. The contaminant inventory for this site is bounded by the 216-U-14 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch. 6. The effluent volume discharged as compared to the soil pore volume suggests a potential for groundwater impact. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07).
216-T-4-1D Ditch	The 216-T-4-1D Ditch was replaced by the 216-T-4-2 Ditch. The area was backfilled and surface stabilized in 1995, along with the 216-T-4-2 Ditch. This ditch was 259 by 2.4 m (850 by 8 ft) and 1.2 m (4 ft) deep.	The ditch received process cooling water from the 221-T and 224-T Buildings via the 207-T Retention Basin and steam condensate from the 221-T Building and 242-T Evaporator and decontamination waste from the 2706-T Building. The 216-T-4-1D Ditch was used from 1944 to 1972, but was inactive from mid-1957 to mid-1964.	--	1.41 (Reference: WIDS)	--	--	--	--	--	--	--	The 216-T-4-1D Ditch is analogous to the 216-U-14 Ditch as indicated by construction and process history and is analogous because of the following. 1. Construction and site configuration of the 216-T-1 Ditch are similar (unlined ditch). 2. The ditch connected the 221-T, 224-T, and 242-T Buildings to the 216-T-4A Pond and later the 216-T-4B Pond, similar to the 216-U-14 Ditch connection to the 216-U-10 Pond. Waste was received from similar sources. 3. The contaminant inventory for this site is bounded by the 216-U-14 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch. 6. Groundwater impact is bounded by the 216-U-14 Ditch. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07).
216-T-4-2 Ditch	The first 15 m (5 ft) of the 216-T-4-2 Ditch, from the head of the unit, was part of the original 216-T-4-1 Ditch. A portion was parallel to the old 216-T-4-1 Ditch, leading to the 216-T-4B Pond. Most of the effluent was absorbed in the first quarter of the ditch. The end of the ditch and the 216-T-4B Pond were often dry. The ditch is backfilled and stabilized. The ditch is 533.8 m (1750 ft) long, 2.4 m (8 ft) wide, and 1.2 m (4 ft) deep.	The ditch received 242-T Evaporator steam condensate and condenser cooling water, and nonradioactive wastewater from 221-T Building air conditioning filter units and floor drains. The ditch was in operation from 1972 to 1995, when it was surface stabilized and backfilled.	--	--	--	--	--	--	1	--	--	The 216-T-4-2 Ditch is analogous to the 216-U-14 Ditch as indicated by construction and process history and is analogous because of the following. 1. Construction and site configuration of the 216-T-1 Ditch are similar (unlined ditch). 2. The ditch connected the 221-T and 242-T Buildings to the 216-4B Pond, similar to the 216-U-14 Ditch connection to the 216-U-10 Pond; however, most of the effluent was absorbed in the first quarter of the ditch. Therefore, the end of the ditch and the 216-T-4B Pond often were dry. 3. The contaminant inventory for this site is bounded by the 216-U-14 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch. 6. Groundwater impact is bounded by the 216-U-14 Ditch. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07).

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2] Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
216-W-LWC	The 216-W-LWC Laundry Waste Crib consists of two independent crib structures (i.e., drain fields) including a central distribution pipe and drain lines with rock fill beneath and 4243 m^3 (5,546 yards) of gravel fill to grade. The 216-W-LWC operated from 1981 to 1994. Each side of the crib is 47 m (150 ft) by 40.5 m (133 ft) and 5.8 m (19 ft) deep with 31.5 cm (1 ft) thick walls. There is 81.1 m (266 ft) of separation between the cribs.	It received waste from the 2723-W and 2724-W Laundry and Mask Cleaning Facilities.	--	--	--	--	--	--	--	1,200,000 Similar to rep site	5,922 Effluent volume to pore volume ratio=203:1	The 216-W-LWC Laundry Waste Crib is analogous to the 216-U-14 Ditch as indicated by source of waste received and is analogous because of the following. 1. Construction and waste site configuration of the 216-W-LWC Crib (gravel-filled crib with PVC distribution lines) and 216-U-14 Ditch (unlined ditch) are dissimilar in construction but similar in that they both are unlined. 2. The site received waste from the 2723-W and 2724-W Laundry and Mask Cleaning Facilities and was a replacement for laundry waste sent to the 216-U-14 Ditch. 3. The contaminant inventory for this site is bounded by the 216-U-14 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch. 6. There is a potential for groundwater impact because the waste discharged to the crib exceeded soil pore volume by a factor of 203.
207-U Retention Basin	The 207-U Retention Basin is a plastic-lined concrete basin divided into halves. It was in operation as a retention basin from 1952 to 1994. It is 75 by 37 m (246 by 123 ft) and 2 m (6.5 ft) deep.	The 207-U Retention Basin received waste from the 221-U and 224-U Buildings where it was held for sampling and discharged to the 216-U-10 Pond via the 216-U-14 Ditch. The 207-U Retention Basin has been modified (by plugging the outlet line), converting the function of the basin into an evaporation pond to support receipt of 224-U Building grounds and storm water runoff.	45	--	--	--	--	--	--	--	--	The 207-U Retention Basin is analogous to the 216-U-14 Ditch as indicated by process history and is analogous because of the following. 1. Construction and waste site configuration of the 207-T Retention Basin (concrete basin) are dissimilar to the 216-U-14 Ditch (unlined ditch). 2. The 207-U Retention Basin was an intermediate transfer point for waste from the 221-U and 224-U Buildings to the 216-U-14 Ditch and the 216-U-10 Pond. 3. The contaminant inventory for this site is expected to be reflective of the 216-U-14 Ditch and the 216-U-10 Pond. 4. The geology of the sites is similar. 5. Evidence of contamination spread is not evident, except for sludge removed from the retention basin and disposed in holes located around the perimeter of the basin and covered with clean dirt (documented as UPR-200-W-111 and UPR-200-W-112). 6. Groundwater impact is bounded by the 216-U-14 Ditch. Leakage has not been documented outside the basin. A contamination survey conducted in the basin in 1977 indicated that no smearable contamination was found.
207-T Retention Basin	The 207-T Retention Basin is a concrete structure, divided into two sections, 75 by 37 m (246 by 123 ft). It had a 3,800,000 L (1,000,000-gal) capacity. Periodically, the sludge that accumulated on the bottom of the basin was cleaned out and placed in holes located around the perimeter of the basin and covered with clean dirt. One of these holes was documented as the 216-T-12 Trench.	The retention basin received T Plant process cooling and ventilation steam condensate, process cooling water from equipment jackets in the 221-T Building, and 224-T Evaporator cooling water and flow from the 221-TA Building via the 216-T-4-2 Ditch. The retention basin was in operation from 1944 to 1995. In 1996, 7.6 to 15.2 cm (3 to 6 in.) of contaminated soil, scraped from adjacent areas, were deposited in the basin, followed by 20.3 to 61 cm (8 to 24 in.) of clean soil.	--	--	--	--	--	--	--	--	--	The 207-T Retention Basin is analogous to the 216-U-14 Ditch as indicated by process history and is analogous because of the following. 1. Construction and waste site configuration of the 207-T Retention Basin (concrete basin) are dissimilar to the 216-U-14 Ditch (unlined pond). 2. The 207-T Retention Basin was an intermediate transfer point for waste from the 221-T and 242-T Buildings to the 216-T-4A and 216-T-4B Ponds; however, not all of the waste from the 221-T and 242-T Buildings was routed to the 207-T Retention Basin (one branch of the 200-W-88 Process Sewer bypassed the 207-T Retention Basin). 3. The contaminant inventory is bounded by the 216-U-14 Ditch. 4. The geology of the sites is similar. 5. Evidence of contamination spread is not evident, except for sludge removed from the retention basin and disposed in holes located around the perimeter of the basin and covered with clean dirt (one such hole was documented as the 216-T-12 Trench). 6. Groundwater impact is bounded by the 216-U-14 Ditch. Leakage has not been documented outside the basin.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2] Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
216-T-12 Trench	The 216-T-12 Trench is a sludge pit used to bury contaminated material from the 207-T Retention Basin. It was only used once. At the time of burial, 15 mrad/h was the maximum detected on the sludge (1954). It has been backfilled and stabilized. It is 4.6 m by 3.1 m (15 ft by 10 ft) and 2.4 m (8.0 ft) deep.	It received contaminated sludge from the 207-T Retention Basin in 1954.	44.6 Less than rep site	1 Less than rep site	--	4.34	2.05	--	--	5,000 Less than rep site	214 Less than rep site Effluent volume to pore volume ratio=23:1 (greater than rep site)	The 216-T-12 Trench is analogous to the 216--U-14 Ditch as indicated by process history and is analogous because of the following. 1. Construction and waste site configuration of the 216-U-14 Ditch (buried concrete culverts) and 216-T-12 Trench (unlined trench) are dissimilar in construction but similar in that they both are unlined. 2. The 216-T-12 Trench received waste from the 207-T Retention Basin, similar to the 216-U-14 Ditch; the waste deposited in the 216-T-12 Trench was sludge removed from the 207-T Retention Basin. 3. The contaminant inventory for this site is more reflective of the 216-T-4A Pond than the 216-T-26 Crib. 4. The geology of both sites is similar. 5. The extent of contamination spread likely will be the same for the 216-T-12 Trench, as compared to the 216-U-14 Ditch, based on the form of material disposed (sludge vs. liquid). 6. The sludge volume discharged and waste form suggest minimal potential for groundwater impact.
200-W-84 Process Sewer	The 200-W-84 Process Sewer is underground, vitrified clay pipeline that is 46 cm (18 in) diameter by 800 m (2,625 ft) long and 0.6 m (2 ft) deep. It terminated at a timber headwall where the flow entered the 216-U-14 Ditch. The process sewer was active from 1952 to 1984.	The process sewer transported 221-U Plant process sewer waste to the 216-U-14 Ditch.	--	--	--	--	--	--	--	--	--	The 200-W-84 Process Sewer is analogous to the 216-U-14 Ditch as indicated by source of waste received and point of discharge, and is analogous because of the following. 1. Construction and waste site configuration of the 200-W-84 Process Sewer (vitrified clay pipe) are dissimilar to the 216-U-14 Ditch (unlined ditch). 2. The 200-W-84 Process Sewer received waste from the same source (221-U Building) and discharged waste to the 216-U-14 Ditch. 3. The contaminant inventory for this site is bounded by the 216-U-14 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch. 6. Groundwater impact is bounded by the 216-U-14 Ditch.
200-W-88 Process Sewer	The 200-W-88 Process Sewer consists of two vitrified clay process sewer pipelines. The southern line extends from the south end of T Plant to the 207-T Retention basin. The northern process sewer line extends from the south end of T Plant and bypasses the retention basin, connecting to the 207-T Discharge Pipe. The total dimensions are 1321 m (4,330 ft) long. The burial depth is 0.6 m (2 ft) wide and 2 m (6.5 ft) deep.	The process sewer received cooling water, air conditioning condensate, and floor drain waste from the 221-T Building, 224-T Building, and 242-T from 1944 to 1995 and was isolated in 1996. The pipelines are associated with the 221-T Building and 207-T Retention Basin.	--	--	--	--	--	--	--	--	--	The 200-W-88 Process Sewer is analogous to the 216-U-14 Ditch as indicated by process history and is analogous because of the following. 1. Construction and waste site configuration of the 200-W-88 Process Sewer (vitrified clay pipe) are dissimilar to the 216-U-14 Ditch (unlined ditch). 2. The ditch connected the 221-T and 242-T Buildings to the 216-4B Pond, similar to the 216-U-14 Ditch connection to the 216-U-10 Pond; however, one of two branches of the 200-W-88 Process Sewer contains the 207-T Retention Basin. 3. The contaminant inventory impact is bounded by the 216-U-14 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch. 6. Groundwater impact is bounded by the 216-U-14 Ditch. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07).
200-W-102 Process Sewer	The 200-W-102 Process Sewer is an underground pipeline used to transfer laundry and mask-cleaning effluent to the 216-U-14 Ditch. It was in operation from 1944 to 1981. Portions of the pipeline are associated with the 2724-U Building foundation. The process sewer is 885 m (2,900 ft) long and 0.6 m (2 ft) in diameter.	The process sewer transported waste from the 2723-W and 2724-W Laundry and Mask Cleaning Facilities to the 216-U-14 Ditch. A portion of the pipeline remained open until 1984 to transfer mask-cleaning effluent to the 216-LWC Crib. In 1981 alone, 26,250 m^3 of wastewater per month was transported in this process sewer.	--	--	--	--	--	--	--	--	--	The 200-W-102 Process Sewer is analogous to the 216-U-14 Ditch as indicated by source of waste received and point of discharge, and is analogous because of the following. 1. Construction and waste site configuration of the 200-W-102 Process Sewer (vitrified clay pipe) are dissimilar to the 216-U-14 Ditch (unlined ditch). 2. The 200-W-102 Process Sewer transferred waste to the 216-U-14 Ditch. 3. The contaminant inventory is bounded by the 216-U-14 Ditch and likely will be lower due to the source of contamination (2723-W and 2724-W Laundry and Mask Cleaning Facilities). 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch. 6. The effluent volume discharged to this crib and contaminant distribution is bounded by the 216-U-14 Ditch. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07).

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
UPR-200-W-111	UPR-200-W-111 is a UPR area consisting of a narrow trench adjacent to the 207-U Retention Basin. It was used once, sometime in the 1960s, to bury approximately 21 m^3 (27 yd^3) of sludge scraped from the bottom of the south side of 207-U Retention Basin. The sludge is covered with 1.2 m (4 ft) of clean soil, surface stabilized in 1997. The dimensions are 12.2 by 4.6 m (40 by 15 ft) and 3.1 m (10 ft) deep.	This UPR area received sludge removed from the 207-U Retention Basin. A radiological survey conducted in 1953 indicated readings as high as 25 rad/h at 20 cm (8 in.) above the waste sludge.	--	--	--	--	--	--	--	--	--	UPR-200-W-111 is analogous to the 216-U-14 Ditch as indicated by process history and is analogous because of the following. 1. Construction is similar (unlined) but configuration is different (sludge disposal trench vs. liquid transfer ditch). 2. UPR-200-W-111 received waste from the 221-U Building, similar to the 216-U-14 Ditch; however, the waste deposited in UPR-200-W-111 was sludge deposited in the 207-U Retention Basin. 3. The contaminant inventory is bounded by the 216-U-14 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch but will be significantly less for UPR-200-W-111 based on the amount (21 m^3 [27 yd^3]) and form of material disposed (sludge vs. liquid). 6. Groundwater impact is bounded by the 216-U-14 Ditch; however, because of the low volume of material disposed and waste form (sludge vs. liquid), groundwater impact will be minimal.
UPR-200-W-112	UPR-200-W-112 is a UPR area consisting of a narrow trench within 3.1 m (10 ft) to the 207-U North Retention Basin concrete wall. It was used once, sometime in the 1960s. It was dug to bury approximately 21 m^3 (27 yd^3) of sludge scraped from the bottom of the south side of 207-U Retention Basin. The sludge is covered with 1.2 m (4 ft) of clean soil, surface stabilized in 1997. The dimensions are 12.2 by 4.6 m (40 by 15 ft) and 3.1 m (10 ft) deep.	This UPR area received sludge removed from the 207-U Retention Basin.	--	--	--	--	--	--	--	--	--	UPR-200-W-112 is analogous to the 216-U-14 Ditch as indicated by process history and is analogous because of the following. 1. Construction is similar (unlined) but configuration is different (sludge disposal trench vs. liquid transfer ditch). 2. UPR-200-W-112 received waste from the 221-U Building, similar to the 216-U-14 Ditch; however, the waste deposited in UPR-200-W-112 was sludge deposited in the 207-U Retention Basin. 3. The contaminant inventory is bounded by the 216-U-14 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-U-14 Ditch but will be significantly less for UPR-200-W-112 based on the amount (21 m^3 [27 yd^3]) and form of material disposed (sludge vs. liquid). 6. Groundwater impact is bounded by the 216-U-14 Ditch; however, due to the low volume of material disposed and waste form (sludge vs. liquid), groundwater impact will be minimal.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1,2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
Representative Site												
216-Z-11 Ditch	The 216-Z-11 Ditch is an unlined ditch, active from 1959 to 1971, backfilled, and surface stabilized in 1971. This ditch is 797 by 1.2 m (2,615 by 4 ft) and 0.6 m (2 ft) deep.	The ditch received waste from the PFP 231-Z, 234-5Z, and 291-Z process sewers to the 216-U-10 Pond.	--	--	--	--	--	--	--	--	--	Characterization is described in DOE/RL-2003-11. <u>Contaminant Distribution</u> Contamination was detected beneath the 216-Z-11 Ditch to 12 m (40 ft) bgs. Maximum concentrations are present from 2.3 to 5.3 m (7.5 to 17.5 ft). Americium-241 and plutonium were the predominant contaminants detected at the ditch bottom, approximately 2.3 to 2.6 m (7.5 to 8.5 ft) bgs with concentrations of 468 pCi/g and 2,780 pCi/g, respectively. Maximum concentrations of Am-241 (919 pCi/g) and plutonium (4,840 pCi/g) were detected about 1.2 m (4 ft) beneath the bottom of the ditch at a depth of 3.7 m (12 ft) bgs. This zone of contamination may represent the bottom of the 216-Z-1D Ditch. The 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches were known to converge in this area to use the culvert passing beneath 16th Street. Americium-241 and Pu-239/240 concentrations decrease with depth to less than 1 pCi/g at depths more than 5.3 m (17.5 ft) bgs. Other radiological contaminants detected in the upper zone of contamination (2.3 to 5.3 m [7.5 to 17.5 ft] bgs) were Ra-226, Sr-90, and Th-230, with maximum concentrations of 58.4 pCi/g, 1.07 pCi/g, 2.73 pCi/g, and 8.43 pCi/g, respectively. At more than 5.3 m (17.5 ft) bgs, the contaminant concentrations were less than 1 pCi/g. Maximum plutonium concentration: 4,840 pCi/g. Maximum Am-241 concentration: 919 pCi/g. Maximum nitrate concentration: 43 mg/kg. Nitrite was detected 3 to 5.3 m (10 to 17.5 ft) bgs with the maximum concentration of 43 mg/kg at a depth of 3 m (10 ft), decreasing with depth to 5.3 m (17.5 ft). TPH was detected 3.0 to 3.8 m (10 to 12.5 ft) bgs at a concentration of 27 mg/kg. Molybdenum is the only inorganic metal that exceeded screening levels in soil samples from borehole C3808, detected 46 to 47 m (152 to 154.5 ft) bgs at 0.82 mg/kg. Plutonium-239, at a depth of 2.9 m (9.5 ft) bgs, was the primary manufactured contaminant identified during logging, estimated at 21,400 pCi/g. Contamination was not detected more than 3.4 m (11 ft) bgs with the RLS. Effluent volume discharged to the Z-Ditch area is not known; therefore, impact to groundwater from the volume of effluent discharges is not known. Contaminants associated with Z-Ditch effluents were not detected below 12.2 m (40 ft). The Z-Ditches mainly were used to channel wastewater to areas of infiltration rather than to percolate wastewater. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07). Results of 216-Z-11 Area modeling indicate that contaminants do not reach groundwater. One important factor to consider in the determination that sites are analogous to the 216-Z-11 Ditch is the proximity of the 216-Z-11 and 216-Z-19 Ditches, the 216-Z-20 Ditch Replacement Tile Field, and the lower portion of the 216-Z-1D Ditch. They are close enough for all of these ditches to be covered by the characterization efforts and results obtained for the representative site (216-Z-11 Ditch).
Analogous waste sites to be evaluated by the 216-Z-11 Ditch model												
216-Z-1D Ditch	The 216-Z-1D Ditch is an unlined ditch, in operation from 1944 to 1959, backfilled, and surface stabilized in 1959. The ditch is 1,295 by 1.22 m (4,250 by 4 ft) and 0.6 m (2 ft) deep.	The ditch received waste from the PFP 231-Z, 234-5Z, and 291-Z process sewers. The 216-Z-1D Ditch is classified as a TRU disposal site.	--	--	--	--	--	--	--	1,000	2,400 Effluent volume to pore volume ratio is <1:1	The 216-Z-1D Ditch is analogous to the 216-Z-11 Ditch as indicated by construction, location, source of waste received and point of discharge, and is analogous because of the following. 1. Construction and waste site configuration are similar (unlined ditches). 2. The 216-Z-1D Ditch received waste from a similar source 234 5Z Building) and discharged to the 216-Z-11 Ditch. 3. The contaminant inventory is bounded by the 216-Z-11 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-Z-11 Ditch. 6. The effluent volume discharged to this crib and contaminant distribution are expected to be similar to the 216-Z-11 Ditch; therefore, the potential for groundwater impact is low. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07). One important factor to consider in the determination that the 216-Z-1-D Ditch is analogous to the 216-Z-11 Ditch is the proximity of the 216-Z-11 and 216-Z-19 Ditches, the 216-Z-20 Ditch Replacement Tile Field, and the lower portion of the 216-Z-1D Ditch. They are close enough for all of these ditches to be covered by the characterization efforts and results obtained for the representative site (216-Z-11 Ditch).

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
216-Z-19 Ditch	The 216-D-19 Ditch is an unlined ditch, in operation from 1971 to 1981, backfilled, and surface stabilized in 1981. The ditch is 843 by 1.2 m (2,765 by 4 ft) and 0.6 m (2 ft) deep. There is 0.6 to 0.9 m (2 to 3 ft) of clean cover over the ditch. The ditch terminates at the 216-U-10 Pond.	The ditch received waste from the PFP 231-Z, 234-5Z, and 291-Z process sewers. In 1976, between 30 and 60 kg of plutonium were released to the ditch. The 216-U-19 Ditch was replaced in 1981 by the 216-Z-20 Ditch Replacement Tile Field.	--	1,400 (Reference: WIDS)	--	--	--	--	--	--	--	The 216-Z-19 Ditch is analogous to the 216-Z-11 Ditch as indicated by construction, location, and point of discharge, and is analogous because of the following. 1. Construction and waste site configuration are similar (unlined ditches). 2. The 216-Z-19 Ditch received waste from a similar source (234 5Z Building) and discharged to the 216-Z-11 Ditch. 3. The contaminant inventory is bounded by the 216-Z-11 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-Z-11 Ditch. 6. Groundwater impact is bounded by the 216-Z-11 Ditch. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07). One important factor to consider in the determination that the 216-Z-19 Ditch is analogous to the 216-Z-11 Ditch is the proximity of the 216-Z-11 and 216-Z-19 Ditches, the 216-Z-20 Ditch Replacement Tile Field, and the lower portion of the 216-Z-1D Ditch. They are close enough for all of these ditches to be covered by the characterization efforts and results obtained for the representative site (216-Z-11 Ditch).
216-Z-20 Ditch Replacement Tile Field	The 216-Z-20 Ditch Replacement Tile Field is an unlined ditch, in operation from 1981 to 1995 that was backfilled and surface stabilized in 1981. It is 463 by 3 m (1519 by 10 ft) with a depth of 2.9 m (9.5 ft). Three perforated PVC pipes run the length of the ditch, backfilled with gravel and soil.	The 216-Z-20 Ditch Replacement Tile Field received cooling water, steam condensate, storm sewer, building drains, HEDL RATDU cooling water, and chemical drain waste from the following buildings: 234-5Z, 231-Z, 291-Z, 232-Z, 236-Z, and 2736-Z.	--	0.148	1.01	0.086	0.063	--	3,400	3,800,000	22,000 Effluent volume to pore volume ratio=173:1	The 216-Z-20 Ditch Replacement Tile Field is analogous to the 216-Z-11 Ditch as indicated by point of discharge and proximity to the representative site, and is analogous because of the following. 1. Construction and waste configuration are similar, although the 216-Z-20 Ditch Replacement Tile Field includes PVC distribution piping that is backfilled with gravel. 2. The 216-Z-20 Ditch Replacement Tile Field received waste from a similar source (234-5Z Building) and discharged to the 216-Z-11 Ditch. 3. The contaminant inventory for this site is bounded by the 216-Z-11 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-Z-11 Ditch. 6. Groundwater impact is bounded by the 216-Z-20 Ditch Replacement Tile Field. From a groundwater perspective, remedial investigations at other OU waste sites suggest that infiltration beneath ditches used to channel wastewater typically is very limited (DOE/RL-99-07). One important factor to consider in the determination that the 216-Z-20 Ditch Replacement Tile Field is analogous to the 216-Z-11 Ditch is the proximity of the 216-Z-11 and 216-Z-19 Ditches, the 216-Z-20 Ditch Replacement Tile Field, and the lower portion of the 216-Z-1D Ditch. They are close enough for all of these ditches to be covered by the characterization efforts and results obtained for the representative site (216-Z-11 Ditch).
207-Z Retention Basin	The 207-Z Retention Basin consists of two concrete basins within one concrete structure. The basins are separated by a 0.3 m (1-ft)-thick concrete wall. Each basin contains a sump with a sump pump. The concrete structure is 15 by 12 m (50 by 40 ft) and 3.1 m (10 ft) deep and was in operation from 1949 to 1959.	The basin received steam condensate and cooling water from the Z Plant Complex (PIF, RECUPLEX, 291-Stack) and released it to the 216-Z-1 and 216-Z-11 Ditches.	--	--	--	--	--	--	--	--	--	The 207-Z Retention Basin is analogous to the 216-Z-11 Ditch as indicated by source of waste received and point of discharge, and is analogous because of the following. 1. Construction and waste site configuration of the 207-Z Retention Basin (concrete basin) are dissimilar to the 216-Z-11 Ditch (unlined ditch). 2. The 207-Z Retention Basin transferred waste to the 216-Z-11 Ditch. 3. The contaminant inventory for this site is bounded by the 216-Z-11 Ditch. 4. The geology of both sites is similar. 5. Extent of contamination is bounded by the 216-Z-11 Ditch; however, a review of associated documentation does not reveal contamination spread outside of the basin. 6. Groundwater impact is bounded by the 216-Z-11 Ditch; however, a review of associated documentation does not reveal contamination spread outside of the basin and potential for groundwater impact is low.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2] Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
UPR 200-W-110	UPR-200-W-110 is a narrow trench east of, and adjacent to, the 216-Z-11 Ditch. It received contaminated backfill material generated during the construction of the 216-Z-19 Ditch. The contaminated backfill was from the 216-Z-1 Ditch. This trench is within the same underground radioactive material zone as the 216-Z-11 Ditch. This one-time release occurred in 1971 and is 130 m (425 ft) long and 4.6 m (15 ft) deep.	UPR-200-W-110 waste originated from the 216-Z-1 Ditch.	--	--	--	--	--	--	--	--	--	UPR-200-W-110 is analogous to the 216-Z-11 Ditch as indicated by source of waste received and proximity to the 216-Z-11 Ditch, and is analogous because of the following. 1. Construction is similar (unlined) but configuration is different (sludge disposal trench vs. liquid transfer ditch). 2. UPR-200-W-110 received contaminated soil, excavated during construction of the 216-Z-19 Ditch, which is analogous to the 216-Z-11 Ditch. 3. The contaminant inventory for this site is bounded by the 216-Z-11 Ditch. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-Z-11 Ditch; however, because of the form of material exposed (contaminated soil), the extent of contamination spread will be lower. 6. Groundwater impact is bounded by the 216-Z-11 Ditch.
Representative Site												
216-A-25 Gable Mountain Pond	The 216-A-25 Gable Mountain Pond was a 29-ha (71-a) pond located in a natural depression north of the 200 Area perimeter fence. The pond operated from 1957 to 1987. The site no longer receives effluent and has an existing soil cover consisting of sand and gravel that ranges from 0.9 to 4 m (3 to 13 ft) thick.	The pond received cooling water and other low-level radioactive effluents from 200 East Area facilities, including the 207-A North Retention Basin.	878	428	--	--	--	--	--	307,000,000	689,620 Effluent volume to pore volume ratio=445:1	Characterization is described in DOE/RL-2000-35. Contaminant Distribution Radionuclides detected include Am-241, Cs-137, Co-60, Sr-90, Pu-239/240, Tc-99, and Eu-154. The greatest level of contamination at Gable Mountain Pond typically is detected and associated with the pond bottom; however, Sr contamination extends to a depth of 11.3 m (37 ft). Contaminant concentration decreases with depth below the pond bottom, with one exception (Sr-90). Strontium-90 and Cs-137 are the major radiological contaminants at the 216-A-25 Gable Mountain Pond and were the only contaminants detected at depths greater than 4.6 m (15 ft) bgs in significant concentrations. The maximum concentrations of Sr-90 and Cs-137 are 58.8 pCi/g and 7,180 pCi/g, respectively. The maximum activity of Cs-137 was associated with the bottom of the pond. The distribution of Sr-90 does not appear to correlate with a particular stratigraphic horizon and was detected throughout the vadose zone at concentrations ranging from not detected to 58.8 pCi/g. The activities of other radiological contaminants typically were less than 2 pCi/g with few exceptions and commonly were observed at less than 4.6 m (15 ft) bgs. Maximum Cs-137: 58.8 pCi/g. Maximum Sr-90: 7,180 pCi/g. Cesium-137 was the only manmade radionuclide detected in boreholes adjacent to the 216-A-25 Gable Mountain Pond. Activities ranged between 0.25 and 0.4 pCi/g and typically occurred less than 1.1 m (3.5 ft) bgs. However, a single detection occurred in borehole 699-55-50D at a depth of 1.8 m (59.5 ft). Groundwater has been impacted by discharges to the pond, most notably a UPR of 7,500 Ci of Sr-90 in 1964 (UPR-200-E-34). A Sr-90 groundwater plume currently is located on the northeast side of the pond. The plume shows virtually no movement because the water table is very flat. The plume, which had a maximum concentration of 1,210 pCi/L in 2001, is not expected to move beyond its current location. Continued or future impacts to groundwater are not expected at this site, based on the low concentrations of mobile contaminants remaining in the soils and the limited infiltration/driving force to move contaminants from the vadose zone to the groundwater.
Analogous waste sites to be evaluated by the 216-A-25 Gable Mountain Pond model												
207-A North Retention Basin	The 207-A North Retention Basin consists of three Hypalon*-lined, concrete basins. Before the liner was installed, the basins had been posted as a Contamination Area, but currently there is no radiological posting. Each basin is 16.8 by 3.0 by 2.1 m (55 by 10 by 7 ft) (total 50.3 m (165 ft) long) and was in operation from 1977 to 1999.	The basins received steam condensate from the 242-A Evaporator, and then it was transferred to the 216-A-25 Crib or the 216-B-3 Pond.	--	--	--	--	--	--	--	--	--	The 207-A North Retention Basin is analogous to the 216-A-25 Gable Mountain Pond as indicated by source of waste received (242-A Evaporator Facility) and point of discharge, and is analogous because of the following. 1. Construction and waste site configuration of the 207-A North Retention Basin (concrete basin) are dissimilar to the 216-A-25 Gable Mountain Pond (unlined pond). 2. The 207-A North Retention Basin transferred waste to the 216-A-25 Gable Mountain Pond. 3. The contaminant inventory for this site is bounded by the 216-A-25 Gable Mountain Pond. 4. The geology is significantly different (much thicker layer of basalt below the 216-A-25 Gable Mountain Pond). 5. Extent of contamination spread is bounded by the 216-A-25 Gable Mountain Pond. Review of associated documentation does not indicate that contamination spread outside of the basin. 6. Groundwater impact is bounded by the 216-A-25 Gable Mountain Pond. Because of the Hypalon* liner installed in the 207-A North Retention Basin and no documentation of basin leakage, the potential impact to groundwater is negligible.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1, 2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			
Representative Site												
216-T-26 Crib	The 216-T-26 Crib consists of four 1.2 m (4 ft) diameter by 1.2 m (4 ft) length concrete culverts, buried vertically with centers spaced 4.6 m (15 ft) apart in a 9.1 by 9.1 by 4.6 m (30 by 30 by 15 ft) excavation.	Tank Farm/T Plant (bismuth phosphate/lanthanum fluoride): 1955-1956. The crib received first-cycle scavenged supernatant waste from the 221-T Building via an underground pipeline and the 216-TY-201 Flush Tank after cascading through the 241-TY-101, 241-TY-103, and 241-TY-104 tanks. It also received scavenged $BiPO_4$ solvent extraction waste from "in plant" and "in tank farm" scavenging operations.	150	59	--	--	--	--	1,000,000	12,000	680 Effluent volume to pore volume ratio=18:1	Investigated in 2001 under DOE/RL-2000-38. Characterization is described in DOE/RL-2002-42 for this representative site. Contaminant Distribution Most of the contamination is in a 16.5-ft zone below the bottom of the crib at 18 ft. The main zone of contamination extends from 18 to 36.5 ft (5.5 to 11 m) bgs. The predominant contaminant is Cs-137. The lower portion of this zone is the approximate top of the Cold Creek unit, where only Tc-99 and H-3 were detected greater than 28.8 m (94.5 ft) bgs. Concentrations were less than 4 pCi/g each in this zone. Maximum Cs-137 concentration occurs from the release site bottom and generally decreases with depth to 11 m (36.5 ft); however, the maximum concentrations of most contaminants occurred in the lower portion of this contaminated zone 34 to 36.5 ft (10.4 to 11 m) bgs. Maximum Cs-137 concentration: 47,900 pCi/g. Maximum Sr-90 Concentration: 49,100 pCi/g. Significant reduction in the levels of contamination is associated with top of the sand-dominated sequence of the Hanford formation and the Cold Creek unit. RLS detected Cs-137 from near the surface to a depth of 128 ft (39 m) bgs. Log data indicate that most of the Cs-137 was detected from 18 to 91 ft (5.5 to 27.7 m) bgs and is distributed deeper in the vadose zone toward the south end of the site. The maximum concentration detected by RLS is estimated to be greater than 3,000 pCi/g.
Analogous Waste Site to be evaluated by the 216-T-26 Crib model												
216-T-36 Crib	The 216-T-36 Crib consists of a single distribution pipe in a gravel layer in a rectangular trench. Backfill covers the pipe and gravel. A long, narrow area of posted contamination adjacent to the east side of the crib appears to be located over the buried pipeline that fed the crib. The crib is 49 by 3.1 m (160 by 10 ft) and 4.6 m (15 ft) deep, and was in operation from 1967 to 1970 or 1973.	The crib received steam condensate, decontamination waste, and miscellaneous waste from the 221-T and 221-U Buildings, and 2706-T Building decontamination waste. The 216-T-36 Crib replaced the 216-T-26 Crib.	1.18 Less than rep site	2.48 Less than rep site	--	3.79	4.36	--	--	522 Less than rep site	3,810 Less than rep site Effluent volume to pore volume ratio is <1:1 (less than rep site)	The 216-T-36 Crib is analogous to the 216-T-26 Crib as indicated by process history and is analogous because of the following. 1. Construction and waste site configuration are similar. 2. The 216-T-36 Crib replaced the 216-T-26 Trench and received waste from the 221-T Building, similar to the 216-T-26 Trench. 3. The contaminant inventory for this site is reflective of the 216-T-26 Crib. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-T-26 Crib but is significantly less because it was in service for a much shorter period and received only 4 percent of the waste. 6. Groundwater impact is bounded by the 216-T-26 Crib. The contaminant inventory and small amount of discharge as compared to the pore volume suggests a low potential to effect groundwater.
200-W-79 Pipeline	The 200-W-79 Pipeline is a 10 cm (4-in.) vitrified clay underground pipeline that fed the 216-T-36 Crib. The pipeline is 225.00 m (738 ft) long and buried 3.1 m (10 ft) deep.	Waste was received from T Plant and U Plant effluent discharges to the 241-T-151 Diversion Box, then the 216-T-36 Crib, and is associated with a 10 cm (4-in.) diameter, vitrified clay pipeline, and adjacent soil.	--	--	--	--	--	--	--	--	--	The 200-W-79 Pipeline is analogous to the 216-T-26 Crib as indicated by process history and is analogous because of the following. 1. Construction and waste site configuration of the 200-W-79 Process Sewer (vitrified clay pipe) are dissimilar to the 216-T-26 Crib (buried concrete culverts). 2. The 200-W-79 Pipeline transferred waste to the 216-T-36 Crib, which replaced the 216-T-26 Crib and received waste from the 221-T Buildings, similar to the 216-T-26 Crib. 3. The contaminant inventory for this site is bounded by the 216-T-26 Crib. 4. The geology of both sites is similar. 5. The extent of contamination spread is bounded by the 216-T-26 Crib. 6. Groundwater impact is bounded by the 216-T-26 Crib.

Table 2-2. Representative Sites and Associated Analogous Waste Sites. (17 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory[1,2]							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total Uranium (kg)	Total Plutonium (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)			

*Hypalon is a registered trademark of Dupont Dow Elastomers Limited Liability Company, Wilmington, Delaware.

[1]Reference: DOE/RL-96-81, unless otherwise noted.
[2]TBP and Na 2Cr2O7 normally would be listed as a contaminant; however, TBP and Na 2Cr2O7 are not present in this 200-CW-2 OU waste site.

DOE/RL-2000-35, *200-CW-1 Operable Unit Remedial Investigation Report.*
DOE/RL-2000-38, *200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan.*
DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit).*
DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units.*
DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations.*
DOE/RL-99-07, *200-CW-1 Operable Unit RI/FS Work Plan and 216-B-3 RCRA TSD Unit Sampling Plan.*
PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001.*
WHC-EP-0698, *Groundwater Impact Assessment Report for the 216-U-14 Ditch.*

bgs = below ground surface.
c/min = counts per minute.
d/min = disintegrations per minute.
HEDL = Hanford Engineering Development Laboratory.
OU = operable unit.
PFP = Plutonium Finishing Plant.
PIF = Plutonium Isolation Facility.
PUREX = Plutonium-Uranium Extraction Plant.
PVC = polyvinyl chloride.
RATDU = Radioactive Acid Digestion Test Unit.
RECUPLEX = Recovery of Uranium and Plutonium by Extraction Plant.
REDOX = Reduction-Oxidation Plant.
RLS = radionuclide logging system.
TBP = tributyl phosphate.
TEDF = Treated Effluent Disposal Facility.
TPH = total petroleum hydrocarbon.
TRU = Waste materials contaminated with 100 nCi/g of transuranic materials having half-lives longer than 20 years.
UPR = unplanned release.
URM = Underground Radioactive Material (area).
WIDS = *Waste Information Data System.*

Table 2-3. Waste Site Risk Summary. (2 Pages)

Risk Element	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	216-A-25 Pond	216-T-26 Crib
Does the site meet human health preliminary remediation goals - chemicals?					
Are concentrations less than WAC 173-340-745?	Yes	Yes	Yes	Yes [(1)]	Yes
Does the site meet human health preliminary remediation goals - radionuclides? Assumes that no credit is taken for the protectiveness of the existing cover.					
Does the waste site meet human health PRGs for radionuclides?	No	No	No	No	Yes
Dose at 0 years (mrem/yr)	2.7×10^3	1.4×10^3	4.5×10^4	1.1×10^3 [(2)]	No contamination from 0 to 4.6 m (0 to 15 ft)
Primary radionuclides that contribute dose, 0 years	Cs-137	Cs-137	Pu-239	Cs-137	NA
Dose at 150 years (mrem/yr)	95	47	4.2×10^4	11 [(2)]	NA
Primary radionuclides that contribute dose, 150 years	Cs-137	Cs-137	Pu-239	Cs-137	NA
Dose at 1,000 years (mrem/yr)	8.2	1.8	3.4×10^4	4.3 [(2)]	NA
Primary radionuclides that contribute dose, 1,000 years	Th-232	K-40	Pu-239	Th-230	NA
Does the site meet human health preliminary remediation goals - radionuclides? Assumes that the existing cover provides some protection.					
Does the waste site meet human health PRGs for radionuclides?	Yes	Yes	Yes	Yes	Yes
Dose at 0 years (mrem/yr)	0.52	1.6×10^{-16}	4.3×10^{-2}	5.7×10^{-2} [(2)]	Not modeled. No contamination from 0 to 4.6 m (0 to 15 ft)
Primary radionuclides that contribute dose, 0 years	Cs-137	K-40	Ra-226	Cs-137	N/A
Dose at 150 years (mrem/yr)	0.163	9.2×10^{-16}	0.25	3.1×10^{-4} [(2)]	N/A
Primary radionuclides that contribute dose, 150 years	Cs-137	K-40	Ra-226	Cs-137; Ra-226	N/A
Dose at 1,000 years (mrem/year)	8.2	5.1×10^{-11}	3.4×10^4	4.4 [(2)]	N/A
Primary radionuclides that contribute dose, 1,000 years	Th-232	K-40	Pu-239	Th-230	N/A
Does the site meet groundwater protection preliminary remediation goals - chemicals?					
Are groundwater protection standards exceeded based on initial screening?	Yes	No	Yes[4]	No [(1)]	Yes
Chemicals predicted to reach groundwater above MCL	Cyanide, fluoride, total uranium	None	None	Not modeled	Cyanide, nitrate, nitrite
Groundwater protection required?	Yes	Yes	No	No	Yes

Table 2-3. Waste Site Risk Summary. (2 Pages)

Risk Element	216-U-10 Pond	216-U-14 Ditch	216-Z-11 Ditch	216-A-25 Pond	216-T-26 Crib
Does the site meet groundwater protection preliminary remediation goals - radionuclides?					
Are groundwater protection standards exceeded based on initial screening?	Yes	Yes	No	No	Yes
Radionuclides predicted to reach groundwater above MCL	Se-79, Tc-99, U-233/234, U-235, U-238	U-233/234 235/238, Tc-99	None	Not modeled	U-233/234/238, Tc-99, Pu-239
Groundwater protection required?	Yes	Yes	No	No	Yes
Does the site meet ecological preliminary remediation goals - chemicals?					
Are concentrations less than ecological PRGs?	No	Yes	Yes	No	Yes
Constituents that exceed PRGs	Selenium	None	None	Arsenic, barium, selenium	None
Does the site meet ecological preliminary remediation goals - radionuclides?					
Are concentrations less than ecological PRGs?	No	No	No	No	Yes
Constituents that exceed PRGs	Cs-137, Sr-90	Cs-137	Am-241, Cs-137, Pu-238, Pu-239, Pu-239/240, Ra-226 Sr-90	Cs-137 Sr-90	None
Ecological protection required?	Yes	No(3)	No(3)	Yes	No
Does the site meet intruder preliminary remediation goals - radionuclides?					
Does the waste site meet intruder scenario PRGs for radionuclides after 150 years?	Yes	Yes	No	Yes	No
Does the waste site meet intruder scenario PRGs for radionuclides after 500 years?	Yes	Yes	No	Yes	Yes

NOTE: This table presents a summary of the constituents identified as primary risk contributors in Appendix C and the constituents identified as a potential groundwater protection concern as discussed in Section 4.6 of the RI Report. RESRAD input parameters are provided in Appendix C. Appendix E contains intruder risk analysis.

1. The 216-A-25 Gable Mountain Pond Site used different statistics and comparison standards than the other sites. See DOE/RL-2000-35, *200-CW-1 Operable Unit Remedial Investigation Report*, for details.
2. The 216-A-25 Gable Mountain Pond Site used different assumptions and exposure scenarios than were used for the other sites. The reported values are conservative with respect to the values reported for the other sites.
3. Although some constituents exceed PRGs, exposure to contaminants in the ditches would tend to be minor relative to the entire area used by an animal because the ditches encompass relatively small areas and have a narrow linear shape such that the contaminated area would typically comprise only a small portion of an animal's home range (i.e., it would be highly unlikely that any individual animal would use *only* the ditch for foraging, shelter, etc.).
4. STOMP results indicate that groundwater protection standards will not be exceeded.

WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."

MCL = maximum contaminant level.
OU = operable unit.
N/A = not applicable.
PRG = preliminary remediation goal.
RESRAD = RESidual RADioactivity (dose model).
RI = remedial investigation.

Table 2-4. Timeframes to Reach Human Health Radiological Preliminary Remediation Goals Through Natural Attenuation.

Waste Site	Contaminant	Time to Reach Human Health PRGs* (years)
216-U-10 Pond	Sum of all radionuclides	280
216-U-14 Ditch	Sum of all radionuclides	210
216-Z-11 Ditch	Sum of all radionuclides	>1,000
216-A-25 Gable Mountain Pond	Sum of all radionuclides	<150
216-T-26 Crib	None	Not applicable

*Timeframes to reach preliminary remediation goals are based on RESRAD modeling and the no-cover scenario.

PRG = preliminary remediation goal.
RESRAD = RESidual RADioactivity (dose model).

Table 2-5. Timeframes to Reach Radiological Ecological Preliminary Remediation Goals Through Natural Attenuation.[a]

Waste Site	Contaminant	Time to Reach Ecological PRGs (years)[b]
216-U-10 Pond	Cs-137 and Sr-90	280
216-U-14 Ditch	Cs-137	Not applicable. Because of to site-specific conditions given in Section 2.7, negligible ecological risks exist at this site.
216-Z-11 Ditch	Am-241, Cs-137, Pu-238, Pu-239, Pu-239/240, Ra-226, Sr-90	Not applicable. Because of site-specific conditions given in Section 2.7, negligible ecological risks exist at this site.
216-A-25 Gable Mountain Pond	Cs-137 and Sr-90	<150
216-T-26 Crib	None	Not applicable. Concentrations already are below PRGs.

[a]Timeframes to reach preliminary remediation goals are based on the no-cover scenario.
[b]It is assumed that timeframes to reach human health PRGs also are ecologically protective.

N/A = not applicable.
PRG = preliminary remediation goal.

Table 2-6. Timeframes to Reach Groundwater Protection Preliminary Remediation Goals[a]

Waste Site	Principal Contaminant	Time to Reach Groundwater Protection Preliminary Remediation Goals (years)
216-U-10 Pond	*Nonradiological* cyanide, fluoride, total uranium	*Nonradiological* >1,000 years
	Radiological Se-79, Tc-99, uranium isotopes	*Radiological* >1,000 years
216-U-14 Ditch	*Nonradiological* sulfide	*Nonradiological* N/A
	Radiological Tc-99, uranium isotopes	*Radiological* >1,000 years
216-Z-11 Ditch	*Nonradiological* None	*Nonradiological* N/A
	Radiological None	*Radiological* N/A
216-A-25 Gable Mountain Pond	*Nonradiological* Not modeled	*Nonradiological* Not modeled
	Radiological none	*Radiological* N/A
216-T-26 Crib	*Nonradiological* cyanide, nitrate, nitrite	*Nonradiological* 250 years
	Radiological Tc-99, uranium isotopes U-233/234/238	*Radiological* >1,000 years

N/A = Not applicable. Concentrations already are below preliminary remediation goals.

Table 2-7. Intruder Risk and Dose Summary.

	Intruder Dose at 150 Years (mrem/year)	**Intruder Dose at 500 Years (mrem/year)**
216-U-10 Pond	3.5	0.12
216-U-14 Ditch	1.8	1.4×10^{-3}
216-Z-11 Ditch(*)	5.5×10^{3} (*)	5.4×10^{3} (*)
216-T-26 Crib	35	0.97
216-A-25 Pond	7.4	0.017

(*)Represents the maximum among the 216-Z ditches.

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CHAPTER 3.0 TERMS

ARAR	applicable or relevant and appropriate requirement
BCG	biota concentration guide
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CLARC	*Cleanup Levels and Risk Calculations under the Model Toxics Control Act Regulation* (CLARC Version 3.1) (Ecology 94-145)
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
FS	feasibility study
HCP	*Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28
MCL	maximum contaminant level
N/A	not applicable
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity (dose model)
ROD	record of decision
RI	remedial investigation
STOMP	Subsurface Transport Over Multiple Phases (code)
TSD	treatment, storage, and/or disposal (unit)

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3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

This chapter defines the land use for the 200-CW-5 Operable Unit (OU), 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OUs and the region, and defines the remedial action objectives (RAO) and preliminary remediation goals (PRG). DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan); DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*; and DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units* (200-CW-5 OU remedial investigation (RI) report), provide initial information on these items for the 200 Areas waste sites. For this feasibility study (FS), Implementation Plan (DOE/RL-98-28) information was compared to data collected during the RI activities and refinements were made as appropriate for the waste sites in this FS.

The RAOs are media-specific or OU-specific objectives for protecting human health and the environment. The RAOs are developed considering land use, contaminants of potential concern (COPC), potential applicable or relevant and appropriate requirements (ARAR), and exposure pathways (conceptual model). The RAOs also specify remediation goals so that an appropriate range of remedial options can be developed for evaluation. This chapter describes the elements used to develop the RAOs and presents the RAOs and remediation goals used to evaluate alternatives.

The RAO process begins by identifying potential future land use and the COPCs for representative waste sites followed by refinement of COPCs to contaminants of concern (COC) once sampling and analysis are completed. This information ensures that the remedial alternatives being considered can adequately address the types of contaminants present, and it facilitates refinement of potential ARARs. The RAOs also provide the basis for developing the general response actions that will satisfy the objectives of protecting human health and the environment. The RAOs are defined as specifically as possible without limiting the range of general response actions that can be applied.

3.1 LAND USE

To identify appropriate cleanup objectives, the future land use of a site must be considered. Current and future land uses of the 200 Areas and the Central Plateau are discussed in the following sections.

3.1.1 Current Land Use

All current land-use activities associated with the 200 Areas and the Central Plateau are industrial in nature. The facilities located in the Central Plateau were built to process irradiated fuel from plutonium production reactors located in the 100 Areas. Most of the facilities directly associated with fuel reprocessing are now inactive and awaiting final disposition. Several waste management facilities operate in the 200 Areas, including permanent waste disposal facilities such as the Environmental Restoration Disposal Facility, low-level radioactive waste burial grounds, and a mixed-waste trench permitted under the *Resource Conservation and Recovery Act of 1976* (RCRA). Construction of tank waste treatment facilities in the 200 Areas began in 2002, and the 200 Areas are the planned disposal location for the vitrified low-activity tank wastes. Past-practice disposal sites in the 200 Areas are being evaluated for remediation and likely are to include institutional controls (e.g., deed restrictions or covenants) as part of the selected remedy. Federal agencies other than the U.S. Department of Energy (DOE), e.g., the U.S. Department of the Navy, use the Hanford Site 200 Areas nuclear waste treatment, storage, and disposal (TSD) facilities. A commercial low-level radioactive waste disposal facility, operated by US Ecology, Inc., currently operates on a portion of a tract in the 200 Areas leased to the State of Washington.

The DOE-selected land use for the 200 Areas, documented through the land-use record of decision (ROD) (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)," is industrial (exclusive) for sites located within the exclusive-use boundary (Core Zone).

According to DOE/EIS-0222-F, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (HCP), industrial (exclusive) land use would preserve DOE control of the continuing remediation activities and would use the existing compatible infrastructure required to support activities such as dangerous waste, radioactive waste, and mixed-waste TSD facilities. The DOE and its contractors and the U.S. Department of Defense and its contractors could continue their Federal waste disposal missions; and the Northwest Interstate Compact for Low-Level Radioactive Waste Management could continue using the US Ecology, Inc., site for commercial radioactive waste. Research supporting dangerous waste, radioactive waste, and mixed-waste TSD facilities also would be encouraged within this land-use designation. New uses of radioactive materials, such as food irradiation, could be developed and the products could be packaged for commercial distribution under this land-use designation.

3.1.2 Anticipated Future Land Use

The reasonably anticipated future land use for the Core Zone, shown in Figure 1-1, is continued industrial (exclusive) activities. Eventually, portions of the Core Zone may be used for non-DOE-related industrial uses. The DOE worked for several years with cooperating agencies and stakeholders to define land-use goals for the Hanford Site and develop future land-use plans (Drummond 1992, *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group)*. The cooperating agencies and stakeholders included the National Park Service, Tribal Nations, states of Washington and Oregon, local county and city governments, economic and business development interests, environmental groups, and agricultural interests. These efforts were initially reported by Drummond (1992) and culminated in the HCP (DOE/EIS-0222-F) and associated ROD (64 FR 61615), which were issued in 1999.

The Future Site Uses Working Group was organized by Federal, Tribal, state, and local governments with jurisdictional interests in the Hanford Site. The Working Group was charged with three related tasks:

- Examine the Hanford Site and identify a range of potential future uses for the Site
- Select appropriate cleanup scenarios necessary to make these future uses possible in light of potential exposure to contamination, if any, after cleanup
- Look for convergences among the Working Group's cleanup scenarios for any priorities or criteria that could prove useful in focusing or conducting the cleanup of the Hanford Site.

The Working Group agreed to seven findings from their activities.

- **The Hanford Site is important.** The Hanford Site has played a significant role in history and continues to be of major economic influence to the area. Cleanup efforts at the Hanford Site, including technology research, may benefit other DOE sites and environmental restoration activities worldwide. Plausible future uses identified include agriculture; industrial and economic development; wildlife and habitat preserves; environmental restoration and waste management activities; public access and recreation; and Native American uses such as hunting, gathering, and religious practices.
- **Cleanup is now DOE's primary mission at the Hanford Site.** As the mission at the Hanford Site transitions from nuclear materials production to supporting national defense to environmental restoration of the area, new challenges emerge for the DOE in the conduct of business, involvement of the public, and accountability for its actions. The Working Group emphasized moving forward with the cleanup and maximizing the potential of the Hanford Site.
- **The Hanford Site will change as cleanup proceeds.** The Working Group envisioned that the area requiring DOE control would shrink in size as the cleanup proceeds, with portions of the site being turned over to other uses once they are no longer needed to support the DOE mission.
- **Both cleanup and future land uses face significant constraints.** Volumes and variety of contaminants and the associated risks pose constraints to the ultimate cleanup, as does the current state of technologies to address these problems. Funding also was identified as a constraint to the timeliness of the cleanup.
- **Native American treaty rights exist.** Treaties signed with the Yakima Indian Nation, the Nez Perce Tribe, and the Umatilla, Cayuse, and Walla Walla Tribes reserved specific rights to the tribes, including those related to hunting, fishing, gathering foods and medicines, and pasturing livestock on open and unclaimed portions of the ceded land, in common with citizens.

- **Uncertainty and risk surround the cleanup.** The current uncertainty about the extent of contamination and the ability of available technologies to address the contamination has produced resulting uncertainties in the future land use.

- **Time is a critical element in focusing the cleanup.** The Working Group expressed a desire that all of the Hanford Site could be used some day for activities other than waste management, but also recognized that technical constraints could affect the timing of the ultimate cleanup and potential future uses.

The Working Group identified nine major recommendations as a result of its efforts.

- **Protect the Columbia River.** Because of the significance of the Columbia River to the region and the Pacific Northwest, the Working Group viewed protection of the river and all of its uses as a high priority.

- **Deal realistically and forcefully with groundwater contamination.** Contaminated groundwater is seen as a threat to the Columbia River and to potential future land uses. The Working Group recommended restrictions on the use of groundwater if it would jeopardize public safety and health. Members also recommended restrictions on the use of groundwater or surface water, contaminated or not, if such use would adversely change hydraulic conditions, increase the spread of contaminated plumes, or increase the speed of contaminated groundwater flow to the river. The Working Group identified areas where restrictions should be applied, recommended removing sources before they reach groundwater, and recommended reducing or eliminating discharges to the soil and treating groundwater.

- **Use the Central Plateau wisely for waste management.** The Working Group recommended consolidation of Hanford Site wastes to the Central Plateau in as small an area as possible. Additionally, waste disposed of at the Central Plateau should not necessarily be considered permanent disposal. Members recommended a buffer zone to reduce risks emanating from the waste management area.

- **Do no harm during cleanup or with new development.** The Working Group recognized that the primary cleanup goal is the protection of human health and public safety, but also noted that environmental values of the site are to be protected and restored. Decisions made in the course of the cleanup and future uses should support these goals and should result in decreased risks to public health and net benefits to the environment. Activities should be guided by the principle "do no harm." Cleanup and future development should be conducted to minimize impacts on plants and animals.

- **Cleanup of areas of high future-use value is important.** While the Working Group supports the cleanup priorities (i.e., current threats to public health or the environment, risk of catastrophic exposure, and technical feasibility) identified by the DOE and the regulators, members also believe that areas of high future-use value should be considered priorities for cleanup. These areas include the Columbia River corridor, the southeast corner of the Hanford Site, areas north of the river, the Fitzner-Eberhardt Arid Lands Ecology Reserve, and the western and northwestern portions of the areas outside the river corridor and the 200 Areas.

- **Cleanup to the level necessary to ensure that the future-use option occurs.** The Working Group believed that "unrestricted" status would support all future-use options, but believed that not all areas would need to be cleaned to unrestricted levels. In fact, the members thought that, in some cases, cleanup to unrestricted levels would cause more harm than good. The Working Group identified cleanup to levels that would be "clean enough for industry" in part of the southeast corner of the site and "clean enough for wildlife" in all other areas (those areas outside the river corridor and the 200 Areas).

- **Transport waste safely and be prepared.** The Working Group recognized that the management and cleanup of waste at the Hanford Site will require shipment of these wastes. Members believed that these shipments affect the public and that close cooperation between the DOE and affected communities should be maintained. The Working Group endorsed preparedness through regulatory means and the use of the Hazardous Materials Management and Emergency Response training facility.

- **Capture economic development opportunities locally.** The Working Group urged the DOE and its contractors to help create the potential for meaningful economic development during cleanup, both onsite and offsite.

- **Involve the public in future decisions about the Hanford Site.** The Working Group recommends that public involvement be incorporated in future decision making at the Hanford Site.

Consistent with the activities of the Working Group, the HCP (DOE/EIS-0222F) was developed. The HCP was written to address the growing need for a comprehensive, long-term approach to planning and development on the Hanford Site because of DOE's separate missions of environmental restoration, waste management, and science and technology. The HCP analyzes the potential environmental impacts of alternative land-use plans for the Hanford Site and considers the land-use implication of ongoing and proposed activities. In the HCP, the land-use designation for sites inside the Core Zone, as shown in HCP Figure 2-233-1, is industrial (exclusive [i.e., those areas suitable and desirable for TSD of hazardous, dangerous, radioactive, and nonradioactive wastes, and related activities]).

Under the preferred land-use alternative selected in the ROD (64 FR 61615), the area inside the Core Zone of the Central Plateau was designated for industrial (exclusive) use. The current vision for all of the 200 Areas is that it will continue to be used for the TSD of hazardous, dangerous, radioactive, and nonradioactive wastes. The HCP and ROD incorporate this vision in the selected alternative, describe the means by which new projects will be sited, and focus on using existing infrastructure and developed areas of the Hanford Site for new projects.
To support the current vision, the 200 Areas projects will maintain current facilities for continuing missions, remediate soil waste sites and groundwater to support industrial land uses, lease facilities for waste disposal (i.e., US Ecology, Inc.), and demolish facilities that have no further beneficial use. Based on the HCP and associated ROD, and consistent with other Hanford Site waste management decisions, this FS assumes an industrial land use for all the waste sites, because they are within the Core Zone. Risk assessments for the industrial land use are conducted considering a non-Hanford Site worker industrial receptor to bound the industrial land-use exposure possibilities.

3.1.3 Regional Land Use

Communities in the region of the Hanford Site consist of the incorporated cities of Richland, West Richland, Kennewick, Pasco, and numerous other smaller communities within Benton and Franklin Counties. The estimated population of the region in 2000 was 186,600, with the population of Benton County being 140,700 and the population of Franklin County being 45,900. There are no residences on the Hanford Site. The inhabited residences nearest to the 200 Areas are farmhouses on land approximately 16 km (10 mi) north across the Columbia River. The City of Richland corporate boundary is approximately 27 km (17 mi) to the south (PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*).

3.1.4 Groundwater Use

The HCP indicates that contamination in the groundwater would restrict use. Groundwater in the Central Plateau currently is contaminated and is not withdrawn for beneficial uses. This FS evaluates potential future impacts to groundwater from current vadose zone contaminants at the representative sites, but does not evaluate groundwater remediation or risks. These issues will be addressed through the evaluation of the groundwater OUs (e.g., 200-UP-1) and through other sitewide assessments.

3.2 CONTAMINANTS OF POTENTIAL CONCERN

Contaminants that have the potential to contribute significantly to site risk are referred to as COPCs. Identification of COPCs is an important process because it determines the list of contaminants for which further risk evaluations will be developed. Development of COPCs in the data evaluation and risk assessment process is discussed in EPA/540/1-89/002, *Risk Assessment Guidance for Superfund (RAGS), Volume 1 – Human Health Evaluation Manual (Part A) Interim Final.* Those contaminants that are COPCs are determined by comparing contaminant concentrations with background, developing a set of data for use in risk assessment, and (if appropriate) limiting the number of contaminants to be carried through a risk assessment by risk-based screening or other methods. The evaluation of COPCs is presented in the RI report (DOE/RL-2003-11) for the 216-U-10 Pond, 216-U-14 Ditch, and 216-Z-11 Ditch representative sites; 200-CW-1 RI report (DOE/RL-2000-35, *200-CW-1 Operable Unit Remedial Investigation Report*) for the 216-A-25 Gable Mountain Pond representative site; and the 200-TW-1 RI report (DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*) for the 216-T-26 Crib representative site. This evaluation is presented in Appendix C for the analogous sites with data as part of the risk assessment. Table C-1 in Appendix C includes a summary of COPCs identified at each representative waste site.

3.3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Appendix B identifies the potential ARARs for the waste sites in this FS.

3.4 REMEDIAL ACTION OBJECTIVES

The RAOs are descriptions of what the remedial action is expected to accomplish (i.e., medium-specific or site-specific goals for protecting human health and the environment). They are defined as specifically as possible and usually address the following variables:

- Media of interest (e.g., contaminated soil, solid waste)
- Types of contaminants (e.g., radionuclides, inorganic, and organic chemicals)
- Potential receptors (e.g., humans, animals, plants)
- Possible exposure pathways (e.g., external radiation, ingestion)
- Levels of residual contaminants that may remain following remediation (i.e., contaminant levels below cleanup standards or below a range of levels for different exposure routes).

The RAOs provide a basis for evaluating the capability of a specific remedial alternative to achieve compliance with potential ARARs and/or an intended level of risk protection for human health or the environment. RAOs specific to the 200 Areas for soils, solid wastes, and groundwater were developed in the Implementation Plan (DOE/RL-98-28). Specific RAOs for this FS were defined based on the fate and transport of contaminants; projected land uses for the 200 Area; and the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU conceptual exposure model. The RAOs for this FS are as follows:

- RAO 1 – Prevent or mitigate risk to human health, ecological receptors, and natural resources associated with exposure to wastes or soil contaminated above potential ARARs or risk-based criteria by removing the source or eliminating the pathway.
- RAO 2 – Prevent migration of contaminants through the soil column to groundwater or reduce soil concentrations below WAC 173-340-747 groundwater protection criteria so that no further degradation of the groundwater occurs from contaminant leaching from soils.
- RAO 3 – Prevent or mitigate occupational health risks to workers performing remedial actions.
- RAO 4 – Prevent destruction of significant cultural resources and sensitive wildlife habitat, minimize the disruption of cultural resources and wildlife habitat in general, and prevent adverse impacts to cultural resources and threatened or endangered species.
- RAO 5 – Provide conditions suitable for future industrial land use of the study area, including appropriate institutional controls and monitoring requirements, to reduce exposure to 15 mrem/yr or less for industrial workers.

The RAOs will be finalized in the ROD for these waste sites. Achievement of the RAOs will be described in the remedial design report/remedial action work plan to be prepared after the ROD is approved. For the purposes of this FS (to determine PRGs), RAO 1 is assumed to be achieved for radionuclides by prevention or reduction of risks from exposure to waste or contaminated soil that exceeds 500 mrem/yr above background for DOE site workers for a period of 50 years from the present and 15 mrem/yr above background for a person who receives maximum exposure under an industrial exposure scenario for the period from 50 years to 1,000 years after final remediation. For carcinogenic chemicals, the first RAO will be achieved by prevention or reduction of risks from waste or contaminated soil in an industrial scenario such that the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) excess lifetime cancer risk (ELCR) goal of 10^{-6} to 10^{-4} cancer risk for carcinogens is not exceeded. For non-carcinogenic chemicals, RAO 1 is defined as prevention or reduction of risks from direct contact with waste or contaminated soils that exceed a hazard quotient or a hazard index of 1. For ecological receptors, exposure to wastes or soil contaminated with radionuclides will be prevented or reduced such that dose rates shall not exceed 0.1 rad/day for terrestrial organisms and 1.0 rad/day for aquatic organisms and terrestrial plants. Exposure of ecological receptors to wastes or soil contaminated with nonradiological constituents will be prevented or reduced so that the hazard quotient and hazard index do not exceed 1.

RAO 2 is satisfied if the following conditions are met; soil concentrations are below WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection," groundwater protection methods or the flux of contaminants into groundwater are reduced to an amount that, in the absence of other groundwater contaminant sources already present from up-gradient sources, results in groundwater concentrations below the MCL.

RAOs 3, 4, and 5 will be achieved by meeting RAOs 1 and 2; by implementing existing Hanford Site standards for protection of cultural resources, wildlife habitat, and industrial workers; and by continuing to enforce existing institutional controls and monitoring requirements.

3.5 PRELIMINARY REMEDIATION GOALS

The PRGs are based on attainment of acceptable levels of human health and ecological risk. Typically, PRGs are identified for individual hazardous substances identified as COCs. COCs are the subset of the contaminants listed as COPCs, in Appendix C, Table C-1, that were determined by the risk assessment in Section 2.6, to exceed applicable standards. If multiple contaminants are present at a site, the suitability of using individual PRGs as final cleanup values protective of human health and the environment is evaluated based on site-specific information and the potential for contaminant interaction.

Meeting these PRGs and the potential ARARs and, by extension, achieving RAOs, can be accomplished by reducing concentrations (or activities) of contaminants to remediation goal levels or by eliminating potential exposure pathways/routes. Contaminant-specific and numeric soil and particulate PRGs for direct exposure and protection of groundwater typically are presented as concentrations (milligrams per kilogram or milligrams per cubic meter) or radioactivity (picocuries per gram), respectively. Final remedial action goals developed from the

PRGs will be specified in a ROD that identifies the selected remedial alternative for the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OUs.

Residual risks following completion of remediation of the waste sites must meet the 10^{-4} to 10^{-6} ELCR for radiological and nonradiological chemical constituents and must be below a hazard index value of 1.0 for non-carcinogens. Actual soil contaminant concentrations achieving these cleanup objectives will be presented in a cleanup verification package for the facility. The cleanup verification package will demonstrate how and where specific criteria have been applied and how the remedy protects receptors from the COCs identified for the waste sites.

3.5.1 Direct Exposure Preliminary Remediation Goals for Nonradioactive Contaminants

Development of the PRGs for direct exposure to nonradioactive contamination for both human and ecological receptors is described in the following subsections.

3.5.1.1 Human Exposure

For human receptors, PRGs for direct exposure to nonradioactive contamination in soils are based on risk-based standards. Risk-based standards for individual hazardous substances are established using applicable Federal and state laws and the risk equations. Risk-based standards for individual carcinogens in an industrial exposure scenario are based on CERCLA guidelines of 10^{-4} to 10^{-6} ELCR. Risk-based standards for individual non-carcinogenic substances are set at concentrations that would result in no acute or chronic toxic effects on human health and the environment; this corresponds to a hazard quotient of less than 1.0. Consistent with this approach, the methodology described for industrial properties under WAC 173-340-745(5), "Method C Industrial Soil Cleanup Levels," is used to calculate the risk-based standards.

Risk-based standards for some contaminants may be less than area background values or practical quantitation limits. Where risk-based standards are less than area background concentrations, PRGs may be set at concentrations that are equal to the agreed-upon site or area background concentrations. Area background values for selected nonradioactive contaminants in soil have been characterized for the Hanford Site (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*). Similarly, where risk-based standards are less than practical quantitation limits, PRGs will default to the practical quantitation limits. Therefore, the PRGs for individual nonradioactive contaminants in solid waste and particulate reflect the value that is greatest among risk-based standards, area background values, or practical quantitation limits. Table 3-1 lists the nonradiological PRGs for direct human exposure for those COCs.

3.5.1.2 Ecological Exposure

The 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OUs are all within the industrial area identified in the HCP (DOE/EIS-0222-F) and within the area designated by the HCP ROD (64 FR 61615) as industrial (exclusive). The industrial (exclusive) land-use designation allows for continued waste management operations within the 200 Areas consistent with past *National Environmental Policy Act of 1969* (NEPA), CERCLA, and RCRA commitments and, among other things, will allow for the development of new waste management facilities. Sites within the Core Zone currently have limited habitat suitable for the establishment of ecological communities and food webs to support a hierarchy of terrestrial receptors. Maintenance of the industrial (exclusive) use will prevent future human inhabitation; however, cleanup to industrial land-use standards may not continue to be protective of ecological receptors after loss of institutional controls. A screening-level ecological risk assessment has been used to develop soil PRGs for the protection of terrestrial wildlife.

Because the waste sites in the FS are all within the Core Zone, only terrestrial wildlife risks will be evaluated. Consistent with this approach, WAC 173-340-7490 (3)(b), "Terrestrial Ecological Evaluation Procedures, Goal," specifies that for industrial or commercial properties, current or potential exposure to soil contamination only need be evaluated for terrestrial wildlife protection. Plants and soil biota need not be considered unless the species is protected under the Federal *Endangered Species Act of 1973*. Currently, no federally listed threatened or endangered species are known to exist on the waste sites. Surveys conducted before field activities will confirm the presence or absence of protected species. For sites with institutional controls that prevent excavation of deeper soil, a conditional point of compliance may be set at the biologically active soil zone, which is assumed to extend to a depth of 2.7 m (9 ft), based on the conditional point of compliance requirements stated in WAC-173-340-7490 (4), "Terrestrial Ecological Evaluation Procedures," "Point of Compliance" (DOE/RL-2001-06, *Comments on Hanford 2012: Accelerating Cleanup and Shrinking the Site*). Priority chemicals of ecological concern and their soil-screening levels are listed in WAC 173-340-900, "Tables," Table 749-3. These soil-screening levels were used in conjunction with the risk assessment to develop PRGs for the COCs that are protective of ecological receptors, as indicated in Table 3-1.

3.5.2 Direct Exposure Preliminary Remediation Goals for Radionuclides

The PRGs for direct exposure to radioactive contamination for both human and ecological receptors are described in the following subsections.

3.5.2.1 Human Exposure

For locations within the Core Zone, the DOE dose limits of 500 mrem/yr for radiological workers will be in effect for as long as waste management operations continue. After a period of 50 years, all waste management facilities are assumed to be closed; however, access to the 200 Areas is assumed restricted for an additional 100 years by enforcement of effective institutional controls. Although institutional controls would still exist after that time, an intruder presumably could obtain access to the area and establish a residence.

After the cessation of waste management operations, remediation goals for radioactive wastes and radioactively contaminated soils for human receptors are considered to be based on the U.S. Environmental Protection Agency (EPA) radionuclide soil cleanup guidance. As established by 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," CERCLA cleanup actions generally should achieve a level of risk within the 10^{-4} to 10^{-6} ELCR based on the reasonable maximum exposure for an individual. Furthermore, EPA policy has noted that the upper boundary of the risk range is not a discrete line at 10^{-4} and that a specific risk estimate around 10^{-4} may be considered acceptable, if justified based on site-specific conditions (EPA/540/R-99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A* [OSWER Directive No. 9200.4-31P]). The goal of remediation is to achieve the 10^{-4} to 10^{-6} risk range, using a dose of 15 mrem/yr above background as an operational guideline to achieve this goal. Demonstration that the 10^{-4} to 10^{-6} residual risk-range goal has been achieved will be accomplished through final verification sampling during closeout of individual sites.

The individual PRGs for the identified COCs are calculated using the RESidual RADioactivity (RESRAD) dose assessment model (ANL/EAD-4, *User's Manual for RESRAD, Version 6*) and are provided in Table 3-2. Numerical values of radionuclide PRGs corresponding to the 15 and 500 mrem/yr guidance limits for the identified COCs depend on the specific exposure scenario selected for remedial design and site-specific parameters (e.g., the area extent of the waste site). Radionuclide PRGs corresponding to the 15 and 500 mrem/yr guidance limits for direct exposure to contaminated soil have been calculated for the industrial scenario, as described in Appendix C.

The soluble salts of uranium present non-carcinogenic toxic effects that are evaluated by a hazard quotient, in addition to the incremental cancer risks presented by the radioactive isotopes of uranium. If the hazard quotient exceeds 1, the possibility exists for systemic toxic effects; however, the dose from total uranium will exceed the 15 or 500 mrem/yr guidance limits at an activity or concentration less than that corresponding to a hazard quotient of 1. Therefore, it is expected that cleanup to meet the radioactivity hazard also will be adequate to address the hazard associated with chemical toxicity.

3.5.2.2 Ecological Exposure

The international community has been involved for more than 20 years in evaluating the effects of ionizing radiation on plants and animals. The International Atomic Energy Agency (IAEA) issued a study in 1992, IAEA 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*, endorsing the 1977 and 1990 International Commission on Radiological Protection (ICRP) reports *Recommendations of the International Commission on Radiological Protection* (ICRP-26 and ICRP-60) and stating that chronic radiation dose rates below 0.1 rad/day will not harm plant and animal populations and that radiation standards for human protection also will protect populations of nonhuman biota. The report implies that dose limits of 0.1 rad/day for animals and 1 rad/day for plants will protect populations, but additional evaluation of effects may be needed if sensitive species are present.

ORNL/TM-13141, *Effects of Ionizing Radiation on Terrestrial Plants and Animals: A Workshop Report*, presents information from a DOE-sponsored workshop held in 1995. The workshop was attended by 12 experts in radioecology and ecological risk assessment. The goal of the workshop was to evaluate the adequacy of current approaches to radiological protection, as exemplified by the IAEA report. The attendees reviewed the DOE's perspective and responsibilities, rationales underlying the IAEA conclusions, and a summary of ecological data from the former Soviet Union. The consensus of workshop participants was that the 0.1 rad/day limit for animals and the 1 rad/day limit for plants recommended by the IAEA are adequately supported by the available scientific information. However, the participants concluded that guidance on implementing the limits is needed and that the existing data support application of the recommended limits for populations of terrestrial and aquatic organisms to representative rather than maximally exposed individuals.

In response to the workshop findings (ORNL/TM-13141), the DOE produced DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, which provides a graded approach to ecological risk assessment for radionuclides and screening-level biota concentration guides (BCG). For radiological constituents, no promulgated screening or cleanup levels are available. The potential effects of surface residual contamination on terrestrial receptors are evaluated by the biota dose assessment committee using the terrestrial radionuclide screening levels presented in DOE-STD-1153-2002. The committee has been assisting the DOE in developing this technical standard, which provides a graded approach for evaluating radiation doses to biota. DOE-STD-1153-2002 provides a cost-effective, easy-to-implement methodology that can be used to demonstrate compliance with DOE dose limits and with findings of the IAEA and National Council on Radiation Protection and Measurements regarding doses below which deleterious effects on populations of aquatic and terrestrial organisms have not been observed. The technical standard also can be used to assess ecological effects of radiological exposure when conducting ecological risk assessments.

The DOE's graded approach for evaluating radiation doses to biota consists of a three-step process that is designed to guide a user from an initial, conservative general screening to a more rigorous analysis using site-specific information (if needed) and is consistent with the eight-step EPA approach for conducting ecological risk assessments. The DOE recommends a three-step process that includes (1) assembling radionuclide concentration data and knowledge of sources, receptors, and routes of exposure for the area to be evaluated; (2) applying a general screening methodology that provides limiting radionuclide concentration values (i.e., BCGs) in soil, sediment, and water; and (3) if needed, conducting a risk evaluation through site-specific screening, site-specific analysis, or a site-specific biota dose assessment conducted within an ecological risk framework, similar to that recommended by EPA/630/R-95/002F, *Guidelines for Ecological Risk Assessment*. Any of the steps within the graded approach may be used at any time, but the general screening methodology is usually the simplest, most cost-effective, and least time-consuming process.

The BCGs contained in the technical standard guidance include conservative screening concentrations that are judged to be protective of the most sensitive terrestrial organisms, assuming a dose of 0.1 rad/day.[1] Each radionuclide-specific BCG represents the limiting radionuclide concentration in environmental media (i.e., soil, sediment, or water) that would not exceed the DOE's established or recommended dose standards for biota protection; therefore, soil concentrations that are less than the BCGs are not considered to pose a threat to terrestrial receptors.

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[1]Terrestrial plant species are assumed to be protected at sites containing a dose of up to 1 rad/day (DOE-STD-1153-2002).

3.5.3 Remediation Goals for the Protection of Groundwater

Remediation goals for the protection of groundwater must address contamination reaching the groundwater and contamination remaining in the ground after remediation (i.e., residual contamination). The remediation goals must consider risk-based standards where contamination might have contacted groundwater and standards for residual contamination that might migrate through the vadose zone to groundwater. Residual vadose zone contamination must be below activities or concentrations that could cause groundwater to exceed protective levels, if contaminants migration occurs. The following subsections present remediation goals for groundwater and for residual contamination in the vadose zone and a discussion of achieving these remediation goals.

3.5.3.1 Nonradionuclide Preliminary Remediation Goals for the Protection of Groundwater

The PRGs for nonradionuclides in the vadose zone that are protective of groundwater are developed from potential ARARs (e.g., MCLs as defined in 40 CFR 141) and published risk-based standards. Consistent with this approach, soil concentrations protective of groundwater are established by evaluating the provisions of WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection," unless it can be demonstrated that a higher contaminant concentration is protective of groundwater (WAC 173-340-747[3][e], "Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods," "Alternative Fate and Transport Models"). Values of soil concentrations protective of groundwater were calculated using formulas from WAC 173-340-747 and inputs from Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*. Table 3-1 provides the PRGs for nonradionuclides identified as COCs.

3.5.3.2 Radionuclide Preliminary Remediation Goals for the Protection of Groundwater

MCLs for radionuclide contaminants in drinking water are specified in 40 CFR 141. Remediation goals for radionuclide contaminants in water, protective of both groundwater and surface water, are based on achieving these MCLs. Remediation goals for radionuclides in water, considered protective of human health, also are considered protective of potential ecological receptors at the groundwater/river interface.

According to 40 CFR 141, the average annual activity of beta particle and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr (40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides"). The MCLs for Sr-90 and tritium are 8 pCi/L and 20,000 pCi/L, respectively (40 CFR 141.66). The MCLs for all other manmade radionuclides causing a 4-mrem/yr dose (except Ra-226 and Ra-228) are calculated based on a 2 L/d drinking water intake using the 168-hour data listed in NBS Handbook 69, *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure*. The EPA has calculated drinking water MCLs for radionuclides in 40 CFR 141, based on NBS Handbook 69. These values of radionuclide drinking water MCLs also are presented in EPA/540/R-00/007, *Soil Screening Guidance for Radionuclides: User's*

Guide (OSWER Directive 9355.4-16A), Table D.2. If two or more radionuclides are present, the sum of their annual dose shall not exceed 4 mrem/yr (40 CFR 141.66).

The MCL for uranium in drinking water is 30 g/L, as promulgated by the EPA (65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule"). Based on the isotopic distribution of uranium on the Hanford Site, the 30 μg/L MCL corresponds to an activity of 21.2 pCi/L (BHI Calculation No. 0100X-CA-V0038, *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level of Total Uranium of 30 Micrograms per Liter in Groundwater*).

For radionuclides in the vadose zone, concentrations of residual contaminants are considered protective of groundwater if the residual levels do not result (via migration through the vadose zone) in concentrations that exceed groundwater remediation goals.

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Table 3-1. Summary of Nonradionuclide Soil Preliminary Remediation Goals for all Pathways.

Constituent	Hanford Site Background[a] (mg/kg)	Direct Contact[b] (mg/kg)	Groundwater Protection[c] (mg/kg)	Terrestrial Wildlife Protection[d,e] (mg/kg)	Overall PRG[f] (mg/kg)
Contaminants of Concern – 216-U-10 Pond					
cadmium	1.0	N/A	0.69	14	1.0
manganese	512	N/A	50	N/A	512
cyanide[g]	--	N/A	0.8	N/A	0.8
selenium	--	N/A	N/A	0.3	0.3
uranium (total)	3.21	N/A	1.3	N/A	3.21
Contaminants of Concern – 216-U-14 Ditch					
None					
Contaminants of Concern – 216-Z-11 Ditch[h]					
Aroclor-1254	--	N/A	0.99	--	0.99
Nitrite	--	N/A	13	--	13
Contaminants of Concern – 216-A-25					
None					
Contaminants of Concern – 216-T-26[g]					
cyanide	--	N/A	0.8	N/A	0.8
nitrate (as N)	52	N/A	40	N/A	40
nitrite (as N)	--	N/A	13	N/A	4

[a]Background concentrations are 90th percentile values of the log normal distribution of sitewide soil background data from DOE/RL-92-24. Where the applicable PRG for a constituent is less than background, the background value is used as the PRG.

[b]Direct contact values represent vadose zone concentrations that are protective of human and ecological receptors from direct contact with contaminated solids. Listed WAC 173-340-745(5) Method C cleanup standards for industrial soil are obtained from the Washington State Department of Ecology CLARC Version 3.1 tables (updated November 2001) (Ecology 94-145) and are used to evaluate the top 4.6 m (15 ft) (WAC 173-340-745).

[c]Values represent vadose zone soil concentrations that will be protective of groundwater. Values are calculated using the WAC 173-340 three-phase model for protection of drinking water (WAC 173-340-747[4], amended February 12, 2001).

[d]Industrial soil levels protective of terrestrial wildlife are obtained from WAC 173-340-900, Table 749-3.

[e]Constituents with values shown are those constituents that exceed their respective soil levels protective of terrestrial wildlife as shown in Appendix C, Table C-14, taking into account the further evaluation of Section 2.8.

[f]Listed values represent the most restrictive soil PRG derived from evaluation of direct contact, groundwater and river protection, and terrestrial wildlife protection. Overall PRGs selected based on terrestrial wildlife protection should be interpreted in light of the discussion in Section 2.8.

[g]These contaminant of concerns, for groundwater protection were not identified in the screening process, but STOMP modeling predicted they would exceed maximum contaminant levels at some point within 1,000 years.

[h]These contaminant of concerns exceeded groundwater protection risk-based soil concentrations; however, subsequent STOMP modeling indicates that these contaminants would not exceed maximum contaminant levels in the groundwater.

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PNNL-11217, *STOMP Subsurface Transport Over Multiple Phases Theory Guide.*
WAC 173-340, "Model Toxics Control Act – Cleanup."
WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."
WAC 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
WAC 173-340-747(4), "Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods," "Fixed Parameter Three-Phase Partitioning Model."
WAC-173-340-900, "Tables."

--	=	No criteria established.
CLARC	=	*Cleanup Levels and Risk Calculations under the Model Toxics Control Act Regulation (CLARC Version 3.1)* (Ecology 94-145).
N/A	=	Not applicable. Not a contaminant of concern for the given exposure route (e.g., direct contact, protection of groundwater, or terrestrial wildlife exposure).
PRG	=	preliminary remediation goal.

Table 3-2. Summary of Radionuclide Preliminary Remediation Goals for All Pathways. (2 Pages)

Constituent	Industrial Direct Exposure[a]	Intruder[b]	Terrestrial Wildlife BCG[c] (pCi/g)	Groundwater Protection[d] (pCi/g)	Overall PRG[e] (pCi/g)	Fraction of Overall PRG[f]
Contaminants of Concern – 216-U-10 Pond[g]						
Cs-137	22.6	N/A	20	N/A	20	200
Eu-154	10.3	N/A	N/A	N/A	10.3	1.2
Se-79	N/A	N/A	--	1.3	1.3	7.7
Sr-90	N/A	N/A	20	N/A	20	7.9
Tc-99	N/A	N/A	N/A	7.6	7.6	1.2
Sum of fractions						218
Contaminants of Concern – 216-U-14 Ditch [g]						
Cs-137	24.2	N/A	20	N/A	20	110
T-99	N/A	N/A	N/A	4.2	4.2	2.8
Sum of fractions						113
Contaminants of Concern – 216-Z-11 Ditch						
Am-241	356	20,000	N/A	N/A	356	210
Cs-137	25	N/A	N/A	N/A	25	38
Pu-239	452	27,000	--	N/A	452	1,700
Pu-240	452	N/A	--	N/A	452	290
Ra-226	7.4	400	N/A	N/A	7.4	700
Sum of fractions						2,940
Contaminants of Concern – 216-A-25						
Cs-137	22.5	N/A	20	N/A	20	360
Sr-90	N/A	N/A	20	N/A	20	2.5
Sum of fractions						363
Contaminants of Concern – 216-T-26 Crib[h]						
Am-241	N/A	11,000	N/A	N/A	11,000	0.02
Cs-137	N/A	11,000	N/A	N/A	11,000	4.4
Pu-239	N/A	15,000	--	N/A	15,000	0.42
Sr-90	N/A	220,000	N/A	N/A	220,000	0.22
Sum of fractions						5.1

Table 3-2. Summary of Radionuclide Preliminary Remediation Goals for All Pathways. (2 Pages)

Constituent	Industrial Direct Exposure[a]	Intruder[b]	Terrestrial Wildlife BCG[c] (pCi/g)	Groundwater Protection[d] (pCi/g)	Overall PRG[e] (pCi/g)	Fraction of Overall PRG[f]

[a]Direct exposure values represent activities for individual radionuclides corresponding to a 15 mrem/yr dose rate in an industrial scenario.

[b]Intruder scenario is described in Appendix E.

[c]Biota concentration in soil that could produce 4 mrem/yr from drinking groundwater.

[d]Concentration in soil that could produce 4 mrem/yr from drinking groundwater.

[e]Listed values represent the most restrictive PRG derived from evaluation of the exposure, terrestrial wildlife, and river protection pathways.

[f]Exposure point concentration divided by the overall PRG. Potential remediation should be sufficient to reduce the sum of these fractions for each site below 1.

[g]STOMP modeling predicted that uranium isotopes also would exceed maximum contaminant levels.

[h]STOMP modeling predicted that uranium isotopes and Tc-99 also would exceed maximum contaminant levels.

DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.*

-- = no criteria established.
BCG = biota concentration guide.
N/A = Not applicable. Not a contaminant of concern for the given exposure route (e.g., direct contact, intruder, protection of groundwater, or terrestrial wildlife exposure).
PRG = preliminary remediation goal.

CHAPTER 4.0 TERMS

DOE	U.S. Department of Energy
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FS	feasibility study
GRA	general response action
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28
ISV	in situ vitrification
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation

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4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE/RL-98-28) (Implementation Plan) provided an initial framework to guide the remedial investigations (RI) in the 200 Areas. The Implementation Plan identified and screened technologies that could be used to address contaminants in the soil and solid waste in the arid 200 Areas environment.

Since the Implementation Plan was issued, additional site characterization information was obtained and RI reports were prepared that presented the nature and extent of contamination and the risk at the representative waste sites. This feasibility study (FS) uses representative sites from three RI reports: DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/ Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units* (200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OUs); DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*) (200-TW-1, 200-TW-2, and 200-PW-5 OUs); and DOE/RL-2000-35, *200-CW-1 Operable Unit Remedial Investigation Report* (200-CW-1 OU).

As part of this FS, additional human health risk assessments and screening-level ecological risk assessments were performed. The results are reported in Chapter 2.0 of this FS. Information from the Implementation Plan and the three RI reports was reviewed against the results of the screening-level ecological risk assessments and human health-risk assessments, and refinements were made to the evaluation of alternatives as appropriate for this FS. A review of technologies was conducted to identify new, emerging technologies and to update information on existing technologies since the writing of the Implementation Plan. If a technology was identified and evaluated in the Implementation Plan and no modifications to this evaluation have been identified, then the technology is mentioned only briefly in this section and the Implementation Plan is referred to for detailed information.

4.1 GENERAL RESPONSE ACTIONS

The initial process of identifying viable remedial action alternatives is described in the Implementation Plan (DOE/RL-98-28) as consisting of the following steps:

1. Define remedial action objectives (RAO)
2. Identify general response actions (GRA) to satisfy RAOs
3. Identify potential technologies and process options associated with each GRA
4. Screen process options to select a representative process for each type of technology based on their effectiveness, implementability, and cost

5. Assemble viable technologies or process options retained in step 4 into alternatives representing a range of removal, treatment, containment, and institutional controls options plus no action.

Chapter 3.0 identified the RAOs for this FS. The Implementation Plan identified preliminary GRAs as follows:

- No action
- Institutional controls
- Containment
- Removal, treatment, and disposal
- Ex situ treatment
- In situ treatment.

These GRAs are intended to cover the range of options necessary to meet the RAOs. Modifications to these GRAs were not necessary, based on the new information collected and evaluated in the RI reports (DOE/RL-2003-11, DOE/RL-2002-42, and DOE/RL-2000-35). Detailed descriptions of each GRA are included in the Implementation Plan.

4.2 SCREENING AND IDENTIFICATION OF TECHNOLOGIES

This section screens and identifies potentially viable technologies for the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU. The initial identification and screening of remedial technologies described in Appendix D (Sections D5.0 to D5.6 and Table D-1) of the Implementation Plan (DOE/RL-98-28) is modified for this FS based on the information obtained from the RIs and the additional risk assessment performed to support this FS. The following subsections summarize the technology screening conducted; discuss the screening of new technologies identified since the creation of the Implementation Plan; and discuss those technologies that are retained for the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU. The technologies are discussed by GRA group. Table 4-1 represents a roadmap for technology selection between the Implementation Plan and this FS.

Potentially applicable technology types and process options were identified and screened in the Implementation Plan in accordance with *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* guidance using effectiveness, implementability, and relative cost as criteria to eliminate those options that are least feasible and to retain those options that are considered most viable.

4.2.1 Rescreening of Implementation Plan Remedial Technologies Based on Risk Assessment Results

Because the initial screening in the Implementation Plan was preliminary, and because additional site-specific risk assessment and characterization information is available, the remedial technologies presented in the Implementation Plan were rescreened for application to the

200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU. The following is a brief screening discussion of the technologies and the results of the refinements.

4.2.1.1 No Action

The National Contingency Plan (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan") requires that a no-action alternative be evaluated as a baseline for comparison with other alternatives. The no-action alternative represents a situation where no restrictions, controls, or active remedial measures are applied to the site. The no-action alternative implies a scenario of "walking away" from the site and taking no measures to monitor or control contamination. The no-action alternative requires that a site pose no unacceptable threat to human health and the environment. The no-action alternative was retained in the Implementation Plan for 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU and is carried forward in this FS.

4.2.1.2 Institutional Controls

Institutional controls consist of (1) physical and/or legal barriers to prevent access to contaminants, (2) monitoring of the groundwater and/or the vadose zone, and (3) maintaining existing soil cover. Institutional controls usually are required when contaminants remain in place at concentrations above cleanup levels; the controls likely will be a component of the remedial alternatives.

Physical methods of controlling access to waste sites are access controls, which include signs, fences, and entry control, artificial or natural barriers, and active surveillance. Physical restrictions are effective in protecting human health by reducing the potential for contact with contaminated media and avoiding adverse environmental, worker safety, and community safety impacts that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal). If used alone, however, physical restrictions are not effective in achieving containment, removal, or treatment of contaminants. Physical restrictions also require ongoing monitoring and maintenance.

Legal restrictions include both administrative and real-property actions intended to reduce or prevent future human exposure to contaminants remaining on site by restricting the use of the land, including groundwater use. Land-use restrictions and controls on real-property development are effective in providing a degree of human-health protection by minimizing the potential for contact with contaminated media. Restrictions can be imposed through land covenants, which would be enforceable by the United States and, under Washington State law, the Washington State Department of Ecology. Land-use restrictions are somewhat more effective than access controls if control of a site transfers from the U.S. Department of Energy (DOE) to another party, because land-use restrictions use legal and administrative mechanisms that already are available to the community and the State.

The disadvantages of land-use restrictions are similar to those for access control: they do not contain, remove, or treat contaminants. In addition, land-use restrictions are not self-enforcing. Land-use restrictions only can be triggered by an effective system for monitoring land use to ensure compliance with the imposed restrictions.

Sampling and environmental monitoring is an integral part of institutional controls and is necessary to verify that contaminants are attenuating as expected, to ensure that contaminants remain isolated, and to ensure that whatever remedial measures are in place are meeting their performance objectives. Periodic sampling activities would include sampling of the actual contaminants and verification of overall site characteristics (geochemical, hydrogeologic, and biological properties). Environmental monitoring would be conducted to ensure that waste containment is achieved and that no further degradation of groundwater occurs. Surface radiation surveys and sampling of local biota may be necessary if contaminants remain near the surface.

Depending on the remedial action taken and results of sampling and monitoring, it will be necessary to maintain the existing soil cover or cap in order to ensure continued isolation of the contaminants.

Based on the results of the RI activities, no changes have been made to this technology from what appeared in the Implementation Plan. The institutional controls technologies will be incorporated into remedial alternatives in Chapter 5.0 for evaluation.

4.2.1.3 Containment

Containment includes physical measures to restrict accessibility to in-place contaminants or to reduce the migration of contaminants from their current location. Containment technologies include surface barriers (caps) and vertical barriers (slurry walls and grout walls), which are used to prevent or limit infiltration and/or intrusion into the contaminated zone.

4.2.1.3.1 Surface Barriers (Capping)

The surface barriers, or capping, technologies are applicable for groundwater, human health, and ecological protection. Several different types of surface barriers have been evaluated for use at the Hanford Site. DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*, evaluated four conceptual barrier designs for different types of waste sites: the Hanford Barrier, the Modified *Resource Conservation and Recovery Act of 1976* (RCRA) Subtitle C Barrier, the Modified RCRA Subtitle D Barrier, and the Standard RCRA Subtitle C Barrier. Based on the results of this evaluation, the Implementation Plan identified three of these engineered barriers as being suitable for use at waste sites in the 200 Area: the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier.

Generally, capping consists of constructing surface barriers over contaminated waste sites to control the amount of water that infiltrates into contaminated media, thereby reducing or eliminating leaching of contamination to groundwater. In addition to their hydrological performance, barriers also may function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate radiation.

The surface barriers proposed in this FS are "evapotranspiration (ET) barriers," which rely predominantly on the water-holding capacity of a soil, evaporation from the near-surface, and plant transpiration to control water movement through the barrier. Precipitation infiltrates at the surface, where it is retained in the soil by absorption and adsorption until ET processes move the water back to the atmosphere. Such designs are particularly suitable for semiarid and arid climates with a low annual amount of precipitation and a relatively high ET potential. When precipitation exceeds ET, water is stored; and when ET exceeds precipitation, water is released. Water balance studies at the Hanford Site have shown that vegetation and soil type control the downward movement of precipitation, and for finer grained soils with a healthy plant cover of shrubs and grasses, net recharge is close to zero (Gee et al. 1992, "Variations in Recharge at the Hanford Site").

The ET barriers can be divided into two categories: capillary barriers and monolithic barriers. The barriers retained in the Implementation Plan (i.e., the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier) are capillary barriers, which consist of a fine-grained soil layer overlying a relatively coarse-grained soil layer. Monolithic barriers rely on a relatively thick single layer of fine-textured soil.

A capillary barrier relies on maintaining a planar textural interface, which would be susceptible to differential settlements or subsidence. This is an important consideration for waste sites with void space or solid waste that are susceptible to subsidence. Differential settlements can disrupt the continuity of layers (i.e., offset layers), which can create large macropores. However, a broad range of options is available (e.g., dynamic compaction, compaction grouting) to mitigate the subsidence potential before barrier construction. Given the same soil type, the monolithic barrier requires additional soil thickness relative to capillary barriers for an equivalent water storage capacity. Should the thickness of the soil required for water-holding capacity exceed the rooting depth, water removal capacity diminishes. However, the additional thickness also can be advantageous in providing increased intruder protectiveness.

The three cap designs retained in the Implementation Plan, the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier, were designed to address various categories of waste (e.g., transuranic, low-level, hazardous, and sanitary). All three designs are ET-type barriers but include additional layers for added levels of containment or redundancy. The term "modified" reflects that the design varies in certain key respects from conventional barrier designs but is expected to be equivalent to, or to exceed the performance of, the conventional design. The Modified RCRA C Barrier design was developed for sites containing hazardous, low-level waste, or low-level mixed waste to provide long-term containment and hydrologic protection for a performance period of 500 years (DOE/RL-93-33). The Modified RCRA C Barrier also was developed because the conventional RCRA C cap design is aimed at areas with much higher precipitation and is not effective for arid climates. The design includes the components of a capillary barrier overlying a secondary barrier system using a low-permeability layer. The secondary barrier layers are provisional, depending on the site-specific need for redundancy in hydrologic protection, a vapor barrier, and/or a more robust biointrusion layer.

The Hanford Barrier design was developed for sites containing greater-than-Class-C low-level waste, and/or significant inventories of transuranic constituents. This barrier remains functional for a performance period of 1,000 years. In addition, of the evaluated designs, the Hanford Barrier provides the maximum available degree of containment and hydrologic protection. The design is composed of nine layers of durable material with a combined thickness of 4.5 m (14.7 ft). The barrier layers are designed to maximize moisture retention and ET capabilities and to minimize moisture infiltration and biointrusion, considering long-term variations in Hanford Site climate.

A 4-year (fiscal years 1995 through 1998) treatability test was completed successfully on a prototype of the Hanford Barrier constructed in fiscal year 1994 over the 216-B-57 Crib. The primary purpose of the test was to document surface barrier constructability, construction costs, and physical and hydrologic performance in support of remedial decision making and remediation at similar waste sites at the Hanford Site. The results of the treatability test are reported in DOE/RL-99-11, *200-BP-1 Prototype Barrier Treatability Test Report*. Results demonstrate that the barrier is easily constructed with standard construction equipment, performance criteria have been met or exceeded, and the Hanford Barrier and associated design components are highly effective. Subsequent to the treatability test, monitoring activities have continued at the barrier. Results of the monitoring activities are reported in annual letter reports, the most recent being CP-14873, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2002*.

The ET barriers have been and continue to be evaluated within the DOE complex (Sandia National Laboratory, Los Alamos National Laboratory, Idaho National Engineering and Environmental Laboratory, Nevada Test Site, Hanford Site), and by the U.S. Environmental Protection Agency. The Alternative Cover Assessment Program, sponsored by the U.S. Environmental Protection Agency, is evaluating a number of field-scale test covers throughout the United States. Results to date indicate that alternative barrier designs at semiarid and arid sites generally exhibit little percolation (Albright et al., 2003, "Examining the Alternatives").

Considering the level of supporting documentation and Hanford Site-specific field data that demonstrate that capillary barriers perform well (DOE/RL-99-11; PNNL-13033, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment*), the Modified RCRA C Barrier is considered to be an appropriate process option for the waste sites in this FS. This process option forms the basis for evaluating capping alternatives at soil waste sites not contaminated with transuranic constituents. The Hanford Barrier is considered to be an appropriate process option for soil waste sites contaminated with significant concentrations of transuranic constituents.

Although the Modified RCRA C Barrier process option is the basis for evaluating this technology, it does not preclude the use of other ET designs (e.g., monolithic barrier). The performance and design parameters would be determined during remedial design. Both the monolithic and capillary barriers have been shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C barrier design, and both have been approved or planned for use in several western states (DOE/RL-93-33).

4.2.1.3.2 Vertical Barriers (Slurry Walls and Grout Walls)

Slurry walls and grout walls were retained in the Implementation Plan (DOE/RL-98-28). Slurry walls are formed by vertically excavating a trench that is filled with a slurry, typically a mix of soil, bentonite, and water, that forms a continuous low-permeability barrier. Grout walls are formed by injecting grout, under pressure, directly into the soil matrix (permeation grouting) or in conjunction with drilling (jet grouting) at regularly spaced intervals to form a continuous low-permeability wall. Using directional drilling techniques, angled grout walls can be formed beneath a waste site. This type of angled barrier is limited (more so than vertical slurry walls) by difficulties in verifying barrier continuity and by the materials used. New innovative materials have the potential for limiting radionuclide mobility through chemical reactions.

Slurry walls and grout walls have potential application in the vadose zone to limit the horizontal movement of moisture into contaminated materials or to limit the horizontal migration of contaminants. Vertical barriers can be used as a supplemental element in the design of surface caps to improve containment performance; both slurry walls and grout walls are suitable technologies for this application.

While the need for horizontal control of contaminant migration has not been identified based on the RI reports (DOE/RL-2003-11, DOE/RL-2002-42, and DOE/RL-2000-35), these options are retained for use in the development of remedial alternatives in Chapter 5.0. These options also are retained for potential future use following the collection and evaluation of confirmatory data to confirm that the appropriate remedial action has been specified for the analogous waste sites.

While use of slurry walls and grout walls has application in this FS as a means of limiting horizontal movement of contamination and water, in particular as part of a capping alternative, suitability of this technology to limit vertical migration of contaminants is less certain. Representative sites in this FS typically have large surface areas (216-U-10 Pond, 216-A-25 Pond), are long narrow ditches (216-U-14 Ditch, 216-Z-11 Ditch), or have contamination at considerable depth (216-U-10 Pond, 216-T-26 Crib). Installation of a horizontal grout barrier beneath these sites would involve considerable difficulty of construction because of the geometry of the sites. For these reasons, the use of slurry walls and grout walls as horizontal barriers to prevent vertical migration of contaminants is not retained in this FS.

4.2.1.4 Removal, Treatment, and Disposal

The Implementation Plan identified excavation of contaminated soils, with treatment as needed to meet disposal criteria, and transportation and disposal to the appropriate disposal facility, as an applicable technology for the waste sites. Excavation of material generally is accomplished using standard earth-moving equipment such as backhoes and front-end loaders. This technology is retained for use at sites as a standalone remedial alternative and in combination with other remedial technologies such as capping. A number of sites in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU have significant contamination in the depth range below 7.6 m (25 ft). As depths increase, there is more chance that the side slope requirements (generally a horizontal:vertical ratio of 1.5:1) will interfere with nearby buildings and facilities.

The levels of contamination in many of the waste sites in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU may pose a significant dose threat to workers. The levels of Cs-137 and Sr-90 and potentially other radionuclides may result in excavation and disposal activities being identified as nuclear activities. In addition, the levels may result in implementing remote-handled removal techniques. Whether remote handled or contact handled, special safety controls will be required to address the contaminant concentrations. These factors are discussed in further detail in Chapter 6.0. Shoring may be needed at cut intervals to reach these depths safely. Large excavations would significantly increase the time that workers are associated with the highly contaminated zones, resulting in increased doses. In addition, large excavations to these depths would put a large amount of contaminated material at risk for spread associated with airborne pathways. Costs would increase because of these increased safety techniques.

Waste disposal is divided into (1) onsite disposal of soils without TRU[1] constituents and (2) temporary onsite storage of soils with TRU constituents, followed by offsite disposal.

- **Waste Disposal of Soils without TRU Constituents**. The onsite disposal option for soils not contaminated with TRU constituents is the Environmental Restoration Disposal Facility (ERDF). The waste acceptance criteria for the ERDF (BHI-00139, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*) are based on regulatory requirements (e.g., RCRA land-disposal restrictions) and risk-based considerations for long-term protection of human health and the environment. If waste cannot be accepted at the ERDF, then a suitable offsite disposal facility will be used; however, all contaminated soils from the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU without TRU constituents are expected to be acceptable to the ERDF.

- **Retrieval, Treatment, and Disposal of Soils with TRU Constituents**. Significant volumes of soil with TRU constituents may be generated from remediation of waste sites in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU (e.g., 216-Z-11 Ditch and other Z-Ditches). If repackaged soil were determined to exceed 100 nCi/g (100,000 pCi/g), it would be transported to the Waste Receiving and Processing facility for waste certification and shipment to the Waste Isolation Pilot Plant in New Mexico.

Because the Waste Isolation Pilot Plant is exempt from RCRA land-disposal restrictions, specific ex situ treatment of mixed TRU waste for organic and inorganic contaminants will not be necessary.

4.2.1.5 Ex Situ Treatment

Ex situ treatment processes retained in the Implementation Plan (DOE/RL-98-28) include thermal desorption, vapor extraction, mechanical separation, soil washing, ex situ vitrification, solidification/stabilization, and soil mixing.

Thermal desorption and vapor extraction technologies typically are applied to soils contaminated with light- to medium-range hydrocarbons and other organics. Thermal desorption also is effective on heavier range hydrocarbons (e.g., diesel, oil). Based on the data contained in the RI reports (DOE/RL-2003-11, DOE/RL-2002-42, and DOE/RL-2000-35) and the results of the risk assessment, remediation for hydrocarbons or organics is not necessary. These ex situ technologies are ineffective for radionuclides and inorganic compounds and, therefore, were rejected for this FS.

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[1]Waste materials contaminated with 100 nCi/g of transuranic materials having half-lives longer than 20 years.

The primary separation technique for solid media using mechanical separation is sieving to segregate material according to size, but other physical properties also may be used as a basis for segregation (e.g., local discoloration of soil). The main disadvantage of this technology is that increased waste handling carries the potential of increased worker risk and the production of fugitive dust. This process has been used as a component of removal and disposal actions on the Hanford Site. Experience in the 300 Area burial grounds has shown that clogging of the sieving device may be a problem. There is no apparent technical advantage to using mechanical separation for the waste sites in this FS. Therefore, the technology is not retained in this FS.

Soil washing has limited effectiveness on many radionuclides, with the risk of higher exposures to workers and potentially high costs associated with the soil washing, especially if chemicals are needed to remove contaminants. Based on the results of the RIs, treatment is not required to meet ERDF or Waste Isolation Pilot Plant waste acceptance criteria. Therefore, soil washing is not retained in this FS.

Ex situ vitrification is costly and is deemed unnecessary to dispose of waste at the ERDF or the Waste Isolation Pilot Plant. Therefore, ex situ vitrification is not retained in this FS.

Solidification/stabilization technologies generally are used to immobilize soil contaminants; this is assumed to be unnecessary for disposal to the ERDF or to the Waste Isolation Pilot Plant. Therefore, solidification/stabilization technologies are not retained in this FS.

Some soil mixing (blending) may be required to meet health and safety standards and waste acceptance criteria before the soils are disposed of at the ERDF. Therefore, soil mixing is retained in this FS.

4.2.1.6 In Situ Treatment

In situ treatment technologies were retained in the Implementation Plan to mitigate contaminant mobility or to treat organics in situ. The technologies are vitrification, grout injection, soil mixing, dynamic compaction, and natural attenuation.

In situ vitrification (ISV) applies an electrical current to melt contaminated soil and forms a stable, vitrified mass when cooled. The stable mass chemically incorporates most inorganics (including heavy metals and radionuclides) and destroys or removes organic contaminants. Experience with ISV, summarized below, indicates that convective mixing that occurs during vitrification will cause the contaminants to be mixed throughout the melt matrix. Air emissions are collected and treated locally. In practice, vapors generated during vitrification are directed from the melt to an offgas hood, then to the offgas treatment system, where vapors are treated using a combination of scrubbers, filtration, and thermal oxidation (if required) before discharge to the environment.

ISV is not considered effective for sites with surface dimensions greater than 12.2 by 12.2 m (40 by 40 ft) or at depths greater than about 6.1 m (20 ft). Therefore, ISV is not suitable for the majority of the sites in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU, either because the contamination is at or below the 6.1 m (20 ft) process depth limit or because the area of the waste sites makes it impractical. However, ISV may be applicable for the 216-Z-11 Ditch and the analogous Z-Ditches, which contain high concentrations of transuranics.

ISV may be acceptable for this specific waste site because the depth of the majority of the contamination is within 5.3 m (17.5 ft) of the surface, which is within the technology's demonstrated effective depth.

At the northern end of the Z-Ditches (where the 216-Z-1D Ditch is located alone), the ditch width is 2.4 m (8 ft). Where the ditches are located side-by-side, the width is 7.3 m (24 ft). Based on these dimensions, approximately 52 ISV operations would be required.

ISV is not a fully matured technology and presents some implementation and performance acceptance challenges in a field environment. Some of these challenges requiring acceptable resolutions are as follows:

- Effective depth
- Assurance of acceptable glass form at the bottom of the melt
- Proper mixing of the soil
- Performance of glass for 1,000 years
- Glass formula evaluation and addition of new material
- In-process sampling analysis accuracy
- Homogeneity of glass formed
- Exposure and radiation levels at the top of the melt.

A number of tests and demonstrations have been conducted to address these issues.

ISV has been shown to be effective at waste sites containing high concentrations of radionuclides and hazardous constituents. The technology was demonstrated most recently at Los Alamos National Laboratory, reported in LA-UR-03-6494, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V)*.

For the Los Alamos National Laboratory demonstration, two demonstration melts were conducted. The first, called the "cold" demonstration, was performed on a simulated absorption bed that contained surrogate contaminants. The second, called the "hot" demonstration, took place in an area containing three absorption beds that received radionuclide- and metal-contaminated wastewater from a laundry facility and a waste research laboratory. Monitoring activities were conducted to track air emissions, melt progression, and glass cooling rate. Sampling and analytical activities included characterization of the absorption-bed materials to confirm the nature and extent of contamination, comparison of pre- and post-demonstration analytical data from the tuff adjacent to the melt to evaluate contaminant migration, chemical and radiological analysis to determine contaminant distribution in the vitrified mass, leaching tests to evaluate glass durability, and mineralogical characterization to evaluate glass homogeneity. Based on the results of the monitoring and sampling conducted during the hot demonstration, the demonstration effectively processed the desired treatment volume, and the resulting glass was both homogeneous and durable. There was no evidence that contaminants were driven from the absorption bed into the surrounding tuff during heating. Furthermore, the offgas recovery and treatment system effectively controlled emissions generated during vitrification. The surface dimensions of the hot demonstration site were 6.4 by 9.1 m (21 by 30 ft). During the demonstration at the Los Alamos National Laboratory, vitrification of the waste was effective to 8 m (26.5 ft).

In 1996, a test was conducted at the AMEC Richland Test Facility to verify that two melting operations conducted in close proximity would fuse together, resulting in no unprocessed waste between the melts. In addition, melts conducted side by side at the Parson's Chemical Works, Inc., site in Grand Ledge, Michigan (EPA/540/R-94/520, *Geosafe Corporation In Situ Vitrification, Innovative Technology Evaluation Report*) demonstrated that melts fuse together without trapping unprocessed waste. Surface dimensions of this demonstration were 8.2 by 8.2 m (27 by 27 ft) and depth averaged 5.2 m (17 ft).

Dose reduction factors are addressed in PNL-4800 SUPP 1, *In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Applications Assessment*. PNL-4800 SUPP 1 indicates that a dose reduction is expected due to self-shielding of the vitrified mass.

Australia used ISV on transuranic-contaminated sites, as reported in ANSTO/C453, *A Report to the Parliamentary Standing Committee on Public Works on Mixing and Encapsulation of Plutonium in In Situ Vitrification Trials at Maralinga*. ANSTO/C453 reports that concentrations of transuranics up to 100 grams per melt were successfully processed. Sampling from these tests showed that plutonium was well mixed throughout the melt, including the porous cold cap that formed on top of the melt, and that there were no localized high concentrations of plutonium. Leachability tests showed that the durability of the resultant product satisfies the DOE criteria for glasses used to immobilize high-level radioactive waste. Dimensions of this demonstration were not given in the report.

ISV is the technology selected for processing TRU-contaminated soil as reported in EPA/541/R-02/100, *Record of Decision (ROD) for Waste Area Group 7, Trenches 5 and 7 in Melton Valley at Oak Ridge National Laboratory*.

Based on the technology development to date, which shows that ISV is likely to meet requirements for long-term stability of waste sites, ISV is retained in this FS.

Grout injection, commonly referred to as jet grouting or in situ grouting, is a process that entails injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into contaminated media. Grouts are specially formulated to encapsulate contaminants, isolating them from the surrounding environment. As summarized in INEEL-01-00281, *Engineering Design File, Operable Unit 7-13/14 Evaluation of Soil and Buried Waste Retrieval Technologies*, in situ grouting has been approved by regulating agencies and implemented at several small-scale sites. However, in situ grouting has not been applied to large-scale sites with many radiological and chemical hazards such as the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU sites. Grout injection, as a standalone action, is rejected for this FS because of the size and depth of the waste sites and its unproven effectiveness on large-scale sites having radiological and chemical hazards. However, the technology is applicable to remedial alternatives to fill voids in pipelines, voids in cribs, and voids in tanks that will remain in place after contamination is removed.

Dynamic compaction is used to increase the soil density, compact the buried solid waste, and/or reduce void spaces by dropping a heavy weight onto the ground surface. The compaction process can reduce the hydraulic conductivity of subsurface soils and, correspondingly, the mobility of contaminants. Because the compactive energy attenuates with depth, dynamic compaction is limited to shallow applications typically less than 3 m (10 ft). Chemicals and radionuclides at the sites in this FS generally are deeper than 3 m (10 ft). For this reason, dynamic compaction is rejected in this FS as a standalone action. Dynamic compaction is retained in the FS as a sub-element of capping; this technology frequently is used to prepare a waste site for cap construction.

Deep soil mixing uses large augers (mixers) and injector head systems to inject and mix solidifying agents (cement or pozzolanic based) into contaminated soil in place. The process reduces the mobility of contaminants by entraining them in the solidifying agent. Soil mixing at depth is difficult to implement in rocky soils, and the effectiveness of solidification of the contaminated soil is difficult to monitor and ensure. Soil mixing is rejected for this FS because of the size and depth of the waste sites to be treated.

Natural attenuation is retained for this FS, because it is a natural component of all of the potential alternatives. Natural attenuation is most effective on sites with nonradionuclides that readily degrade in the environment and on sites with radionuclides that have short half-lives, such as Cs-137. However, natural attenuation is a slow process at sites that have radionuclides with long half-lives (e.g., plutonium and uranium) or nonradionuclides that do not degrade naturally in the environment. It may be the only feasible and cost-effective technology for sites that have deep contamination, because other technologies (e.g., retrieval and in situ treatment) are difficult to implement, ineffective, and potentially cost prohibitive.

4.3 SUMMARY OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS RETAINED FOR THE 200-CW-5 OPERABLE UNIT, 200-CW-2 OPERABLE UNIT, 200-CW-4 OPERABLE UNIT, AND 200-SC-1 OPERABLE UNIT ALTERNATIVE DEVELOPMENT

Based on the screening presented in Section 4.2, Table 4-1 shows the remedial technologies and process options that have been retained for development of remedial alternatives specific to the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU.

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Table 4-1. Technology Types and Process Options for Soil. (2 Pages)

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units
No action	None	Not applicable	Yes	Yes
Institutional controls	Land-use restrictions	Deed restrictions	Yes	Yes
	Access controls	Signs/fences	Yes	Yes
		Entry control	Yes	Yes
	Monitoring	Groundwater	Yes	Yes
		Vadose Zone	Yes	Yes
		Air	Yes	Yes
	Surface barriers	Existing soil cover	No	Yes
Containment, including ET barriers	Surface barriers	Hanford Barrier	Yes	Yes
		Modified RCRA and other ET Caps	Yes	Yes
		Standard RCRA Caps	No	No
		Asphalt, concrete, or cement-type cap	No	No
	Vertical barriers	Slurry walls	Yes	Yes
		Grout curtains	Yes	Yes
Removal	Excavation	Conventional	Yes	Yes
		High contamination	No	Yes
Disposal	Landfill disposal	Onsite landfill	Yes	Yes
		Offsite landfill/ repository	Yes	Yes
Ex situ treatment	Thermal treatment	Thermal desorption	Yes	No
		Vitrification	Yes	No
	Physical/chemical treatment	Vapor extraction	Yes	No
		Soil washing	Yes	No
		Mechanical separation	Yes	No
		Solidification/ stabilization	Yes	No
		Soil mixing	Yes	Yes

Table 4-1. Technology Types and Process Options for Soil. (2 Pages)

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units
In situ treatment	Thermal treatment	Vitrification (Z-Ditches)	Yes	Yes
	Chemical/physical treatment	Vapor extraction	Yes	No
		Grout injection (pipelines and tanks)	Yes	Yes
		Deep soil mixing	Yes	No
		Dynamic compaction (component of capping)	Yes	Yes
	Natural attenuation	Natural attenuation	Yes	Yes

DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program.*

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

ET = evapotranspiration.
RCRA = *Resource Conservation and Recovery Act of 1976.*

CHAPTER 5.0 TERMS

ALARA	as low as reasonably achievable
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FS	feasibility study
ISV	in situ vitrification
N/A	not applicable
NCP	"National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300)
OU	operable unit
PRG	preliminary remediation goal
RAO	remedial action objective

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5.0 REMEDIAL ACTION ALTERNATIVES

The U.S. Environmental Protection Agency (EPA) guidance for conducting feasibility studies under *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) recommends that a limited number of technologies be carried forward from the technology identification and screening activity; these technologies then are grouped into remedial alternatives to address the site-specific conditions. In Chapter 4.0, technologies were identified and screened based on site-specific characteristics and contaminants of concern. In this chapter, these technologies are grouped into remedial alternatives to address site contamination problems. Several remedial alternatives are developed and described in this chapter for the waste sites in the 200-CW-5 Operable Unit (OU), 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU. The applicability of these alternatives to the individual waste sites also is considered.

5.1 DEVELOPMENT OF ALTERNATIVES

Significant efforts and evaluations have contributed to defining applicable technologies and process options that address the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU representative and analogous waste sites. The *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE/RL-98-28) (Implementation Plan), Appendix D, provides initial information on identification and screening of remedial technologies for 200 Area waste sites. The Implementation Plan, in conjunction with Chapter 4.0 of this feasibility study (FS), represents a Phase I FS and thus forms the basis for the development of remedial alternatives. The Implementation Plan also preliminarily develops remedial alternatives based on the results of the technology screening for the waste sites. Remedial alternatives identified in the Implementation Plan for the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU include the following:

- No action
- Monitored natural attenuation/institutional controls
- Removal, treatment, and disposal (onsite disposal and geologic repository)
- Containment using surface barriers
- In situ grouting or stabilization
- In situ vitrification (ISV).

Table 5-1 illustrates the process of identifying technology types, combining process options, and presenting the elements of each alternative. Evaluation of the no-action alternative is a requirement under CERCLA. The monitored natural attenuation/institutional controls alternative is retained and further developed in this FS for sites where existing remedial actions are in place or where contamination is expected to reach remedial action objectives (RAO) within a reasonable institutional controls period. The removal, treatment, and disposal alternative and the containment using surface barriers alternative also are retained and further developed in this FS.

The ISV alternative is retained for consideration at the Z-Ditches only, due to their relatively high TRU[1] content and physical dimensions. The in situ grouting or stabilization alternative, as a standalone alternative, is screened out of this FS because of implementation problems associated with the size and depth of the waste sites and unproven effectiveness on large-scale sites having radiological and chemical hazards. In situ grouting or stabilization technologies are, however, retained for inclusion as elements of other remedial actions. This FS developed one additional alternative that was not identified in the Implementation Plan. This alternative is a combination alternative that includes partial removal, treatment, and disposal with subsequent capping. The following subsections further develop and describe the alternatives.

One important factor in the development of site-specific remedial alternatives is that radionuclides, heavy metals, and some inorganic compounds cannot be destroyed. As such, these compounds must be physically immobilized, contained, or chemically converted to a less mobile or less toxic form to meet the RAOs.

5.2 DESCRIPTION OF ALTERNATIVES

This section provides a description of the selected alternatives considered for evaluation in this FS, including the following:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Capping
- Alternative 5 – Partial Removal, Treatment, and Disposal with Capping
- Alternative 6 – ISV.

5.2.1 Alternative 1 – No Action

The "National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300) (NCP) requires that a no-action alternative be evaluated as a baseline for comparison with other remedial alternatives. The no-action alternative represents a situation where no legal restrictions, access controls, or active remedial measures are applied to the site. No action implies "walking away from the waste site" and allowing the wastes to remain in their current configuration, affected only by natural processes. No maintenance or other activities are instituted or continued. Selecting the no-action alternative would require that a waste site pose no unacceptable threat to human health or the environment.

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[1]Waste materials contaminated with 100 nCi/g of transuranic materials having half-lives longer than 20 years.

Based on the waste site evaluations and the results of the risk assessment, only one of the representative sites in this FS may meet the RAOs using the no-action alternative (216-B-64 Retention Basin). The no-action alternative is carried forward in this FS for comparison purposes and to address analogous waste sites that are expected to meet the RAOs and PRGs without any action.

5.2.2 Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

This alternative takes advantage of existing soil covers and the nature of the contaminants (such as the natural attenuation of Cs-137 and Sr-90 that have relatively short half-lives), in combination with institutional controls, to provide protection of human health and the environment. Monitoring also is an element of this alternative. For most of the waste sites in these OUs, an existing soil cover is present that is associated with the actual construction of the waste site (i.e., the waste site was constructed at depth and clean backfill was placed in the excavation to the surface) and with surveillance and maintenance activities, where additional soil was added to stabilize the waste sites. Under this alternative, these existing soil covers would be maintained and/or augmented as needed to provide protection from intrusion by human and/or biological receptors. Institutional controls, including legal and physical barriers, also would be used to prevent human access to the site. The existing soil covers and/or caps would break the pathway between human and ecological receptors and the contaminants. WAC 173-340-745(7), "Soil Cleanup Standards for Industrial Properties," "Point of Compliance," identifies the points of compliance for different pathways as follows.

- "For soil cleanup levels based on protection of groundwater, the point of compliance shall be established in the soils throughout the site."
- "For soil cleanup levels based on protection from vapors, the point of compliance shall be established in the soils throughout the site from the ground surface to the uppermost groundwater saturated zone."
- "For soil cleanup levels based on human exposure via direct contact or other exposure pathways where direct contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to fifteen feet below the ground surface."

WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," specifies a standard point of compliance at 4.6 m (15 ft) for ecological receptors; institutional control is not required under this option. WAC 173-340-7490 also specifies a conditional point of compliance at the biologically active soil zone, with a requirement for institutional controls. The regulation assumes a 1.8 m (6 ft) below ground surface (bgs) biologically active zone, but a site-specific zone may be established.

Based on literature searches regarding the root and burrowing depths of vegetation and animals present on the Hanford Site, a sufficient soil thickness to prevent biological intrusion generally would be 2.4 to 3.0 m (8 to 10 ft). Most of the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU waste sites have a soil cover (i.e., surface stabilization, backfill) over the contaminated zone of only a few feet. Soil covers at the analogous sites may be different than the soil covers at their associated representative sites.

Institutional controls involve the use of physical barriers (fences) and access restrictions (deed restrictions) to reduce or eliminate exposure to contaminants of concern. Institutional controls also can include groundwater, vadose, surface soil, biotic, and/or air monitoring. Institutional controls for this alternative include periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, manual removal, or other activities to control deep-rooted plants; control of deep burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; and site reviews.

For sites having a clean soil cover of less than 4.6 m (15 ft), more stringent institutional controls (e.g., physical and legal barriers) would need to be implemented to address potential risks from direct human and ecological contact with the contaminants. Water and land-use restrictions also would be used to prevent exposure.

Contaminants remaining beneath the clean soil cover would be allowed to naturally attenuate until remediation goals are met. Natural attenuation relies on natural processes to lower contaminant concentrations until cleanup levels are met. Monitored natural attenuation would include sampling and/or environmental monitoring, consistent with EPA guidance (EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites November 1997, Draft Interim Final,* OSWER Directive No. 9200.4-17P), to verify that contaminants are attenuating as expected. Attenuation monitoring activities could include monitoring of the vadose zone using geophysical logging methods or groundwater monitoring to verify that natural attenuation processes are effective.

The existing network of groundwater monitoring wells in the Central Plateau is adequate for monitoring most sites, in coordination with the groundwater OUs (200-BP-5, 200-PO-1, 200-UP-1, and 200-ZP-1). Where the existing network is unsatisfactory, additional monitoring wells are planned. If remediation activities result in the decommissioning of groundwater monitoring wells in the area of remediation, an evaluation of future monitoring needs will be conducted.

5.2.3 Alternative 3 – Removal, Treatment, and Disposal

Under this alternative, contaminated soil would be removed, treated if required to meet waste acceptance criteria, and disposed of to an appropriate facility. Some soil blending may be required to meet health and safety standards and waste acceptance criteria. A generalized cross-section for this alternative is shown in Figure 5-1. The disposal facility chosen depends on the type of waste to be disposed. The majority of the waste generated under this alternative would be disposed of at the Environmental Restoration Disposal Facility (ERDF). For waste sites with transuranic constituents above levels of concern (i.e., 100 nCi/g), disposal to a geologic repository would be required. As reported in DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the*

200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units, plutonium and americium levels in the Z-Ditches exceed 100 nCi/g.

5.2.3.1 Sites without Concentrations of TRU Constituents at Levels of Concern

Soil and associated structures (such as cribs) with contaminant concentrations above the PRGs would be removed using conventional excavation techniques where appropriate, or specialized excavation techniques where contamination levels require added protection (these specialized techniques are discussed in greater detail in Chapter 4.0). Excavated materials would be disposed of at an approved disposal facility, currently envisioned as the ERDF. Precautions would be used to minimize the generation of onsite fugitive dust. Depending on the configuration and depth of the area to be excavated, shoring might be required to comply with safety requirements and to reduce the quantity of excavated soil. The depth, and therefore the volume, of soil removed largely depend on the categories of PRGs that are exceeded. For example, if human health direct contact or ecological PRGs are exceeded, removals generally would be conducted to a maximum of 4.6 m (15 ft) in line with the points of compliance identified in WAC 173-340-745 and WAC 173-340-7490. If groundwater protection is required, soils would be removed to meet groundwater protection PRGs. Table 5-2 shows the excavation depths required for this alternative at each representative site. Risk assessment to support the data in Table 5-2 is contained in Chapter 2.0. Below-grade structures extending below 4.6 m (15 ft) would be removed, if practicable, or stabilized in place. Figure 5-1 illustrates how excavation generally would proceed under this alternative. Implementability, short-term risk to workers, and cost need to be evaluated to determine appropriate excavation depths and to drive decisions between removal and other remedial actions, such as capping.

The remediation of soil and associated structures for this alternative would be guided by the observational approach. The observational approach is a method of planning, designing, and implementing a remedial action that relies on information (e.g., samples, field screening) collected during remediation to guide the direction and scope of the effort. Data are collected to assess the extent of contamination and to make "real-time" decisions in the field. Targeted (or hot spot) removals could be considered under this alternative if contamination were localized in only a portion of a waste site.

Based on existing information, soil and/or debris removed from the waste sites do not require treatment to meet ERDF waste acceptance criteria (BHI-00139, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*). However, additional activities are required to meet health and safety requirements during excavation, handling, transportation, and disposal. Highly contaminated soil will be blended with less contaminated soil to achieve as low as reasonably achievable (ALARA) goals and to reduce worker risks at all points in the removal and disposal process. Contaminated soil and structures will be containerized (e.g., containers, burrito wraps, bulk shipment) on site and transported to the ERDF, located in the 200 West Area.

After the PRGs are met, uncontaminated soil would be used to backfill the excavation. The backfill material could be found at a variety of sources, including local borrow pits and any remaining excavated material that is determined to be clean (verified as clean by meeting the PRGs). Following remediation, the site will be recontoured, resurfaced, and/or revegetated to establish natural site conditions. Maintenance of the site is required until the vegetation is sufficiently established to prevent intrusion by noxious, non-native plants such as cheatgrass or Russian Thistle.

5.2.3.2 Sites Potentially Contaminated with TRU Constituents at Levels of Concern

The 216-Z-11 Ditches have americium and plutonium levels that exceed the TRU definition (>100 nCi/g) as identified through DOE/RL-2003-11. The TRU contamination is confined to a relatively thin layer at the bottom of the ditches, between a depth of approximately 1.2 and 3.0 m (4 and 10 ft) bgs. Waste sites with transuranic constituents potentially above 100 nCi/g are classified as pre-1970s waste sites, because disposal to all these waste sites occurred in the 1950s and 1960s.

Under this alternative, contaminated soil would be retrieved, verified as non-TRU waste or TRU waste by sampling and analysis, treated if necessary, temporarily stored, and disposed of at the Waste Isolation Pilot Plant, if required. Excavation of soil and waste containing transuranic constituents at levels of concern has been performed at many U.S. Department of Energy (DOE) sites, including Hanford, Idaho National Engineering and Environmental Laboratory (INEEL-01-00281, *Engineering Design File, Operable Unit 7-13/14 Evaluation of Soil and Buried Waste Retrieval Technologies*), Rocky Flats, Savannah River, and others. For soil sites, standard or modified excavation equipment would be used to retrieve the soil and waste until PRGs are met. Equipment for removal of TRU-contaminated soil and waste is proven and available. Any clean overburden soil removed would be stockpiled in an adjacent onsite area. Precautions would be used to minimize the generation of onsite fugitive dust. Depending on the configuration of the area to be excavated, shoring might be required to comply with safety requirements and to reduce the quantity of excavated soil. Characterization before excavation would be required to confirm that TRU levels exist at the waste site and to minimize the amount of soil and waste classified as TRU. TRU and non-TRU soils and waste would be segregated during retrieval and would be further tested to minimize the amount disposed of at the Waste Isolation Pilot Plant. Wastes acceptable for disposal at the Waste Isolation Pilot Plant would be sent there, and treatment is not deemed necessary to meet waste acceptance criteria. Packaging of the soil and waste for disposal at the Waste Isolation Pilot Plant most likely would occur at the site during excavation, but also could be performed in a separate storage facility. Details would be determined during design, once more precise information on the location, volume, and concentration of TRU contamination were determined.

Following retrieval of the waste, the site would be backfilled with clean soil and recontoured, resurfaced, and/or revegetated to establish natural site conditions. Maintenance of the site is required until the vegetation is sufficiently established to prevent intrusion by noxious, non-native plants such as cheatgrass or Russian Thistle.

5.2.4 Alternative 4 – Capping

The capping alternative consists of constructing surface barriers over contaminated waste sites to control the amount of water that infiltrates into contaminated media, in order to reduce or eliminate leaching of contamination to groundwater. These barriers may include vertical slurry or grout walls to limit intrusion of water from the sides. In addition to their hydrological performance, barriers also can function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate radiation. Additional elements to the capping alternative include institutional controls, discussed earlier, and monitored natural attenuation, where contamination undergoes natural processes in a reasonable amount of time. This is particularly important for waste sites that have elevated contamination levels with depth that pose a threat to groundwater or to potential intruders past the institutional controls period. For example, some of the waste site bottoms are located below 4.6 m (15 ft), so the soil above the waste site is clean backfill. However, in association with the waste site bottoms, sampling has shown elevated concentrations of radionuclides (mainly Cs-137 and Sr-90) extending from the bottom of the waste site for tens of feet. More mobile contaminants also are found at greater depths in the waste sites. This contamination presents a zone of exposure to future intruders to the waste sites and a potential threat to the groundwater. Therefore, the capping alternative would have to consider layers or other actions that would prevent, or at least warn, potential intruders of the hazard.

The preferred capping technology for the Hanford Site is an evapotranspiration (ET) barrier, as shown in Figure 5-2. The ET surface barriers rely on the water-holding capacity of a soil, evaporation from the near-surface, and plant transpiration to control water movement through the barrier. Non-TRU sites could have a variety of ET barriers; the most appropriate one would be determined during design. The Modified *Resource Conservation and Recovery Act of 1976* (RCRA) Subtitle C Barrier design (Figure 5-3) is used as the basis for evaluating this alternative; this does not preclude the use of other ET designs (e.g., monolithic barrier). Monolithic and capillary barriers have been shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C Barrier design, and both have been approved or planned for use in several western states (EPA 2003, *Remediation Technology Descriptions,* "Alternative Landfill Cover Project Profiles;" and DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*). The TRU sites may require barrier performance similar to the Hanford Barrier (Figure 5-4). Both are described in detail in Chapter 4.0.

If capping is identified as the preferred alternative, finalization of site-specific designs will occur as part of the remedial design process and will consider the RAOs and requirements defined in the record of decision, regulatory design and performance standards, material availability, cost effectiveness, current surface barrier technology information, and site-specific hydrologic and physical performance requirements to ensure waste containment. Different waste sites likely will have varying barrier performance requirements, and more than one barrier design (e.g., monolithic and capillary barrier) may be deployed to address waste site capping needs.

When groundwater protection is required, the cap will limit the infiltration of precipitation. When the prevention of ecological and human intrusion is a performance requirement, then the physical barrier components to the cap become more important. The capping alternative includes provisions for groundwater monitoring for those waste sites with contamination predicted to threaten groundwater maximum concentration levels.

Performance monitoring of the Hanford Barrier, installed at the 216-B-57 Crib in 1994, has shown essentially no water infiltration through the barrier (CP-14873, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2002*). The effectiveness of the cap is related to the design, which must be specific to the conditions at the waste site, and to continued monitoring activities. Some recent preliminary fate and transport modeling for the BC Cribs and Trenches area has shown that reducing the infiltration rate to 0.1 mm/yr by use of a cap would cause a five-fold reduction in the resulting groundwater concentration versus that for uncapped sites. Additional modeling will be needed to design an appropriate cap to achieve the most effective protection of groundwater.

Use of a capping alternative would require an assessment of the lateral extent of contamination during the confirmatory and/or remedial design sampling phases to properly size the cap to ensure containment. The site-specific extent of contamination can be assessed using a variety of approaches including, but not limited to, process knowledge, previous site investigations, geophysical logging, and/or soil sampling. Some degree of oversizing of the barrier beyond the footprint of the waste zone (referred to as overlap) is expected and is dependent on the barrier design used and the depth of contamination. For the purposes of this FS, an overlap of 6.1 m (20 ft) is assumed based on the performance of the Hanford Barrier. The type and availability of barrier construction materials also is a design consideration. The results of the most recent investigation (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) will be considered during remedial design for selection of the barrier construction materials.

Caps require surveillance and maintenance throughout their life to ensure continued protection. To ensure that the cap is performing as designed, performance monitoring will be conducted. Performance monitoring for this alternative will be twofold. The first component is groundwater monitoring. The second component is vadose zone monitoring, if practical. This FS assumes a fairly robust performance monitoring effort during the first 5 years after construction, followed by a more focused effort in subsequent years. The effectiveness of institutional controls to maintain the cap becomes uncertain past 150 years. For the majority of the sites in this FS, a design life of 500 years is considered sufficient, because the contaminants decay to protective levels at the surface within 500 years. For barriers that use naturally stable geologic materials, the key factor establishing life expectancy is projected wind-erosion rates, which will be minimized by maintaining the vegetation cover, adding gravel to the upper portion of the surface layer, or by using other armoring methods.

5.2.5 Alternative 5 – Partial Removal, Treatment, and Disposal with Capping

Under Alternative 5, contaminants would be removed to the maximum depths listed in Table 5-2. These are depths considered protective of human health from direct contact and intruder scenarios and protective to ecological receptors. Risk assessment to support the data in Table 5-2 is contained in Chapter 2.0. Following excavation, the waste site would be backfilled with clean borrow soil and capped as discussed above. These activities would remove a fraction of the near-surface contamination load. The removal, treatment, disposal, and capping activities would be the same as or similar to those described in Chapter 4.0 and in the preceding subsections. However, removal activities would not be aimed at removing all contaminants in the vadose zone. They would be aimed at reducing the mass of contamination associated with the bottom of the waste site, which, in turn, would in turn, reduce the potential intruder risk. The disposal option would be the same. The required cap would be less rigorous than if these contaminants were left in place because the inadvertent intruder risk is significantly reduced.

For example, instead of a Hanford Barrier, a monofill soil barrier may be appropriate. The actual design of the barrier would be determined through the detailed design activities.

If contaminants are not in the 0 to 4.6 m (0 to 15 ft) zone, then the resulting risk reduction to humans and ecological receptors from direct contact to shallow-zone contamination would be zero. The point of compliance for direct exposure is the 0 to 4.6 m (0 to 15 ft) zone, so contaminants deeper than this only would reduce the risk to intruders. Contaminants that impact the groundwater may be located deeper in the vadose zone. Therefore, the removal of contaminants to mitigate the direct contact and intruder human health risk may not significantly change the risk to groundwater. The capping activity provided in this alternative would address protection of groundwater from the remaining contaminants in the vadose zone. Institutional controls would be an additional requirement for this alternative, because contamination above PRGs is left on site.

It is possible that, in some cases, the level of contamination in the vadose zone below the level of excavation will not be a threat to groundwater, in which case a cap would not be required (i.e., Alternatives 3 and 5 would be identical).

5.2.6 Alternative 6 – In Situ Vitrification

As pointed out in Chapter 4.0, ISV is not suitable for the majority of the sites in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU, either because the contamination is at or below the 6.1 m (20 ft) process depth limit or because the area of the waste sites make it impractical. ISV is not considered effective for sites with surface dimensions greater than 12.2 by 12.2 m (40 by 40 ft).

According to DOE/RL-2003-11, the 216-Z-11 Ditch and the other Z-Ditches have transuranic radionuclide concentrations that exceed 100 nCi/g down to a depth of 3 m (10 ft). Levels of TRU contamination less than 100 nCi/g, along with fission product contamination, continue to a depth of 5.3 m (17.5 ft) bgs. The 216-Z-1D Ditch and 216-Z-11 Ditch contaminants are classified as pre-1970s TRU, because disposal occurred in the 1940s through 1960s (although, the 216-Z-11 Ditch was decommissioned in 1971). Because of the large potential volume of TRU-contaminated waste under the Z-Ditches, ISV is considered to be a potential alternative for this particular site. The site is long and narrow, which puts it within the acceptable spatial constraints of ISV (about 12.2 by 12.2 by 6.1 m deep [40 by 40 by 20 ft]), provided multiple melts are used along the length of the ditch. ISV would appear to be a potentially attractive alternative to capping (which would be more difficult due to the geometry of the ditches) and excavation (which would be more difficult due to the need to handle transuranics, plus the cost of shipping transuranics to the Waste Isolation Pilot Plant if they exceed 100 nCi/g after packaging).

In the ISV process, the waste is converted to a glass form that is highly resistant to erosion. The extent to which ISV mitigates ecological risks will depend on the characteristics of the final waste form and the ecological receptors of concern. Implementation of ISV will mitigate groundwater risk, because the final waste product is a non-leachable waste form. The extent to which ISV will mitigate direct radiation dose at the site is uncertain, but most of the human exposure at the Z-Ditches is from alpha-emitting transuranics, which do not generally create significant direct radiation dose. If the transuranics are bound in a stable matrix, the human health risk will decrease. Nonetheless, it may be necessary to cap the site following ISV, to decrease exposure to Cs-137, which is not removed but is bound in the stable matrix.

Once ISV operations are concluded, the resulting matrix would be sampled to verify quality, leachability, homogeneous mixing of contaminants, etc., especially in locations between and underneath melts to verify complete melting of the contaminated soil. Sampling would be accomplished using techniques similar to those described in LA-UR-03-6494, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V)*: use of a hollow-stem auger rig with a diamond-impregnated epoxy coring bit, and others. Los Alamos National Laboratory reported that, because of the hardness of the glass, several diamond bits were required. Sampling under the melt could be accomplished with conventional slant drilling. Analyses likely would be similar to those performed at Los Alamos, which included target analyte list metals, toxicity characteristic leaching procedure metals, radionuclides by gamma spectroscopy, isotopic plutonium, isotopic uranium, Sr-90, and inorganic chemicals and radionuclides in PCT product consistency test.

The ISV alternative may require continuing institutional controls and monitoring to protect against intrusion and to verify that the design specifications for immobilization are met. Use of the ISV alternative for long-lived radioisotopes (specifically, the TRU contamination in the Z-Ditches) must recognize that the effectiveness of institutional controls beyond 150 years is uncertain, and it is therefore important that the final waste form have long-term stability. Tests and natural analogs have shown vitrified waste to have such long-term stability.

5.3 REFERENCES

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WAC 173-340-745(7), "Soil Cleanup Standards for Industrial Properties," "Point of Compliance," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

Table 5-1. Summary of Remedial Alternatives and Associated Components.

Technology Type	Process Option	Alternative 1 – No Action	Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls	Alternative 3 – Removal, Treatment, and Disposal	Alternative 4 – Capping	Alternative 5 – Partial Removal, Treatment, and Disposal with Capping	Alternative 6 – In-Situ Vitrification
No action	No action	X					
Land-use restrictions	Deed restrictions		X		X	X	X
Access controls	Signs/fences		X		X	X	X
	Entry control		X		X	X	X
Monitoring	Groundwater		X	X	X	X	X
	Vadose zone		X		X	X	X
	Air		X	X	X	X	X
Surface barriers	Existing soil cover		X		X		X
	Evapotranspiration barriers				X	X	
In situ physical treatment	Dynamic compaction				X	X	
	Grout injection				X[a]	X[a]	
In situ thermal treatment	In situ vitrification						X[b]
Ex situ physical treatment	Soil mixing			X		X	
Removal	Conventional excavation			X		X	
	Excavation in high concentration areas			X		X	
Landfill disposal	Onsite landfill			X		X	
Monitored natural attenuation	Offsite landfill/ repository			X[c]	X[c]	X[c]	
	Monitored natural attenuation	X	X	X	X	X	X

[a]For filling pipelines or tanks and for stabilizing cribs or other subsurface structures to prepare for placement of a cap.
[b]In situ vitrification is applicable to the 216-Z-Ditches only.
[c]Disposal of soils from waste sites with transuranic constituents at concentration of concern (i.e., greater than 100 nCi/g).

Table 5-2. Depth of Excavation for Alternative 3 – Removal, Treatment, and Disposal and Alternative 5 – Partial Removal, Treatment, and Disposal with Capping.

Representative Site	Excavation Depth* of Chemical Contamination to Meet Groundwater PRG (ft)	Excavation Depth* to Remove Direct Contact Risk (ft)	Excavation Depth* to Remove Ecological Risk (ft)	Excavation Depth* of Radiological Contamination to Meet Groundwater PRG (ft)	Excavation Depth* to Remove Intruder Risk (ft) at 150 years	Alternative 3 Excavation Depth* (ft)	Alternative 5 Excavation Depth* (ft)
216-U-10 Pond	210	15	15	210	0	210	15
216-U-14 Ditch	15	15	0	15	0	15	N/A
216-Z-11 Ditch	11	15	11	0	15	15	N/A
216-A-25 Pond	0	0	15	0	0	15	N/A
216-T-26 Crib	150	0	0	200	30	200	30

*Depth is measured in feet below ground surface.

N/A = not applicable because near-surface contamination is removed in Alternative 3.
PRG = preliminary remediation goal.

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CHAPTER 6.0 TERMS

ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FS	feasibility study
ISV	in situ vitrification
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
PRG	preliminary remediation goal
RAO	remedial action objective
STOMP	Subsurface Transport Over Multiple Phases (code)
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
WIPP	Waste Isolation Pilot Plant

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6.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents the detailed analysis of the remedial alternatives described in Chapter 5.0 for the 200-CW-5 Operable Unit (OU), 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU waste sites included in this feasibility study (FS). The remedial alternatives are evaluated relative to seven of the nine *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) criteria, described in the next section. The remedial alternatives are evaluated for each representative site to determine if the CERCLA evaluation criteria are met.

Analogous waste sites were assigned to representative sites based on physical similarities and similarities in the expected distribution of contamination using available information and process knowledge. For this reason, analogous sites are assumed to have contaminant distributions and risks similar to the representative site. Therefore, the detailed analysis for the representative site is assumed to be appropriate for the analogous site. The assignments of analogous sites to representative sites are explained in detail in Chapter 2.0.

The detailed analysis is presented by alternative. Within each alternative, each representative site is compared with each of the CERCLA evaluation criteria. Tables 6-1 through 6-5 provide a summary of the detailed analyses for the representative sites and their respective analogous sites.

The representative sites analyzed are as follows:

- 216-U-10 Pond (located within the 200-CW-5 OU)
- 216-U-14 Ditch (located within the 200-CW-5 OU)
- 216-Z-11 Ditch (located within the 200-CW-5 OU)
- 216-A-25 Pond (located within the 200-CW-1 OU)
- 216-T-26 Crib (located within the 200-TW-1 OU).

The analysis of the alternatives takes into account the nature of the contaminants at each site and the assumed land use. Currently, the land use for the 200 Areas is industrial in nature, associated with the management of waste. This land use can be reasonably predicted to be the same for the next 50 years, given the U.S. Department of Energy's (DOE) current commitment to vitrify waste in the tank farms. Industrial use is assumed for the foreseeable future.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The U.S. Environmental Protection Agency (EPA) has developed nine CERCLA evaluation criteria, defined in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, (Interim Final)*, OSWER 9355.3-01, to address the statutory requirements and the technical and policy considerations important for selecting remedial alternatives. These criteria serve as the basis for conducting detailed and comparative analyses and for the subsequent selection of appropriate remedial actions.

The nine CERCLA evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirement (ARAR)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are threshold criteria. Alternatives that do not protect human health and the environment or those do not comply with ARARs (or do not justify a waiver) do not meet statutory requirements and are eliminated from further consideration in this FS.

The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are balancing criteria on which the remedy selection is based. The CERCLA guidance for conducting an FS lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA/540/G-89/004). The detailed analysis process in this chapter addresses these questions, providing a consistent basis for the evaluation of each alternative.

The final two criteria, state and community acceptance, are modifying criteria. The criterion of state acceptance will be addressed in DOE/RL-2004-26, *Proposed Plan for the 200-CW-5 (U Pond/Z Ditches), 200-CW-2 (S Pond/Ditches), 200-CW-4 (T Pond/Ditches) Cooling Water Group, and 200-SC-1 Steam Condensate Group Operable Units*), prepared by the DOE, EPA, and Washington State Department of Ecology (Ecology) (Tri-Parties). The Proposed Plan will identify the preferred remedy (or remedies) accepted by the Tri-Parties. The criterion of community acceptance will be evaluated following the issuance of the Proposed Plan for public review and comment.

In addition to the CERCLA criteria, *National Environmental Policy Act of 1969* (NEPA) values have been incorporated into this document. Assessment of these considerations is important for the integration of NEPA values into CERCLA documents, as called for by the *Secretarial Policy on the National Environmental Policy Act* (DOE 1994) and DOE O 451.1A, *National Environmental Policy Act Compliance Program*. Potential effects on NEPA values also are discussed in this chapter.

6.1.1 Overall Protection of Human Health and the Environment

This criterion determines whether adequate protection of human health and the environment, including preservation of natural systems and biological diversity, is achieved through implementation of the remedial alternative. Protection includes reducing risk to acceptable levels, either by reducing contaminant concentrations or by eliminating potential routes for exposure, and minimizing exposure threats introduced by actions during remediation. Environmental protection includes avoiding or minimizing impacts to natural, cultural, and historical resources. This criterion also evaluates the potential for human health risks, the extent of those risks, and whether a net environmental benefit will result from implementing the remedial alternative.

This first criterion is a threshold requirement and is the primary objective of the remedial action program. As indicated in EPA guidance, this criterion, and the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness, overlap (EPA/540/G-89/004). This FS used the CERCLA risk range of 1×10^{-4} to 1×10^{-6} excess lifetime cancer risk (ELCR) for human health as the range of protectiveness. Alternatives were measured against this standard to determine if the alternative meets this criterion. Protection of groundwater was measured against groundwater protection standards derived from the maximum contaminant levels identified in 40 CFR 141, "National Primary Drinking Water Regulations," and in fate and transport modeling, reported in DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*, and Appendix C of this FS. Ecological compliance was judged using WAC 173-340-900, "Tables," and DOE/STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs are any appropriate standards, criteria, or limitations under any Federal environmental law or more stringent state requirement that must be either met or waived for any hazardous substance, pollutant, or contaminant that will remain on site during or after completion of a remedial action. The ARAR identification process is based on CERCLA guidance (EPA/540/2-88/002, *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Sites*; EPA/540/G-89/004). Potential Federal and state chemical-, location-, and action-specific ARARs associated with remediation of the waste sites addressed in this FS are presented in Appendix B, and each alternative is assessed for compliance against these ARARs. When an ARAR cannot be met, the lead agency can request a waiver if there is a solid basis for justifying the waiver. Several of these ARARs address the protection, restoration, or enhancement of fish and wildlife habitat and other natural, cultural, and historical resources.

6.1.3 Long-Term Effectiveness and Permanence

This criterion addresses the results of a remedial action in terms of risks that remain at the site after remedial action objectives (RAO) are met. The primary focus of this evaluation is the extent and effectiveness of the controls that could be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion are considered for each alternative:

- Magnitude of residual risk to human and ecological receptors. This factor assesses the residual risk from untreated waste or treatment residue after remedial activities are completed. The characteristics of the residual waste are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and reliability of controls. This factor assesses the adequacy and suitability of controls used to manage treatment residues or untreated wastes that remain at the site. It also assesses the long-term reliability of management controls for providing continued protection from residues, and it includes an assessment of the potential need to replace the alternative's technical components.

A related consideration is the restoration time required to reestablish sustainable environmental conditions, including fish and wildlife habitat and cultural resources, where appropriate. Residual risk to natural and cultural resources after conclusion of remedial activities also is evaluated. Current environmental conditions are assessed against the alternative's long-term and permanent solutions. The assessment considerations are based on whether lasting environmental losses would be incurred for the sake of short-term cleanup gains, including whether environmental restoration and/or mitigation options would be precluded if a remedial alternative were implemented.

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the degree to which a remedial alternative reduces the toxicity, mobility, or volume of a hazardous substance through treatment. Significant overall reduction can be achieved by destroying toxic contaminants or by reducing total mass, contaminant mobility, or total volume of contaminated media.

This criterion focuses on the following factors for each alternative:

- The treatment processes used and the materials treated
- Whether recycling, reuse, and/or waste minimization are used in the treatment process
- The type and quantity of treatment residuals that remain following treatment, and whether any special treatment actions will be needed
- Whether the alternative satisfies the statutory preference for treatment as a principal element.

6.1.5 Short-Term Effectiveness

This criterion evaluates the potential effects on human health and the environment during the construction and implementation phases of a remedial action. This criterion also considers the speed with which an alternative achieves protection. The following factors are considered for each alternative:

- Health and safety of remediation workers and reliability of protective measures taken. Specifically, this involves any risk resulting from implementation, such as fugitive dust, transportation of hazardous materials, or air quality impacts from offgas emissions.
- Physical, biological, and cultural impacts that might result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated.
- The amount of time for the RAOs to be met.

Short-term human health impacts are closely related to the duration of exposure to hazardous waste and the risks associated with waste removal. The greater the exposure time, the greater the risk. Guidelines will be followed during implementation of the remedial action to minimize worker risks and maintain radiation exposures as low as reasonably achievable (ALARA).

Short-term environmental impacts are related primarily to the extent of physical disturbance of a site and its associated habitat. Risks also can be associated with the potential disturbance of sensitive species (e.g., bald eagles) because of increased human activity in the area.

6.1.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials.

The following factors are considered for each alternative:

- Technical feasibility
  - The likelihood of technical difficulties in constructing and operating the alternative
  - The likelihood of delays because of technical problems
  - Uncertainties related to innovative technologies (e.g., failures)
- Administrative feasibility
  - Ability to coordinate activities with other offices and agencies
  - Potential for regulatory constraints to develop (e.g., as a result of uncovering buried cultural resources or encountering endangered species)

- Availability of services and materials
  - Availability of adequate onsite or offsite treatment storage capacity, and disposal services, if necessary
  - Availability of necessary equipment, specialists, and provisions to ensure obtaining any additional resources, if necessary.

6.1.7 Cost

This criterion considers the cost of implementing a remedial alternative, including capital costs, operation and maintenance costs, and monitoring costs. The cost evaluation also includes monitoring of any restoration or mitigation measures for natural, cultural, and historical resources.

The cost estimates for the purposes of this study are presented in either 2003 constant dollars or present-value terms. The cost estimates were prepared from information available at the time of this study. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, the competitive market conditions, and other variables. However, most of these factors are not expected to significantly affect the relative cost differences of alternatives.

6.1.8 State Acceptance

This criterion evaluates the technical issues and concerns that the EPA and Ecology could have regarding a remedial alternative. The regulatory acceptance process would involve a review and concurrence by the EPA and the Ecology. This criterion will be addressed at the time that the Proposed Plan (DOE/RL-2004-26) is published.

6.1.9 Community Acceptance

This criterion evaluates the issues and concerns that the public may have regarding a remedial alternative. This criterion will be addressed following public review of the proposed plan.

6.2 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of the alternatives evaluated under an industrial (exclusive) land-use scenario. This section is followed by a NEPA evaluation. Detailed evaluations were performed on all representative sites. Data obtained at the representative sites were used to evaluate analogous sites. Furthermore, for costing purposes, all sites within the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU are grouped in logical units for remedial actions.

The following detailed evaluations are applicable to the representative waste sites and their respective analogous sites. Unless noted, when a site name is used, it means the representative site plus any associated analogous site(s).

6.2.1 Detailed Analysis of Alternative 1 – No Action

Alternative 1 is retained for detailed analysis as a baseline description of the effects of taking no action and is required by CERCLA regulations.

6.2.1.1 Overall Protection of Human Health and the Environment

For the five representative waste sites addressed by this FS, the no-action alternative would fail to provide overall protection of human health and the environment because contaminants at concentrations above the preliminary remediation goals (PRG) would remain on site with no measures performed to prevent intrusion to the contaminants or to monitor their migration. Therefore, for these five representative sites, this alternative fails to meet this criterion under CERCLA. Likewise, for all of the analogous waste sites, the no-action alternative fails to meet this criterion. The one analogous waste site, the 216-B-64 Retention Basin, is the exception. This retention basin, although pre-operationally tested with non-contaminated liquid, was never used. As a result, risks to human health and the environment under current conditions are anticipated to be within acceptable limits.

6.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Because no action would be taken to control the exposure pathway, this alternative would not meet the ARARs for the waste sites, except for analogous site 216-B-64 Retention Basin. For this site, all ARARs are anticipated to be met under Alternative 1 because the retention basin never was used for its intended purpose of receiving steam condensate effluent.

ARARs include risk-based concentrations for soil cleanup that, if exceeded, would result in a radiological dose of 15 mrem/yr or greater under an industrial scenario. As shown in Table 2-3, the dose rate for four of the five sites (all except the 216-T-26 Crib) exceeds 15 mrem/yr assuming that no credit is taken for protectiveness of the existing cover. The appropriateness of the 15 mrem/yr end dose is discussed in EPA (1997), OSWER 9200.4-18, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination,* and clarified in EPA/540/R-99/006, OSWER Directive 9200.4-31P, *Radiation Risk Assessment at CERCLA Sites: Q & A.*

Appendix E contains an analysis of risk to an inadvertent intruder and indicates that an inadvertent intruder would receive a dose in excess of 15 mrem/yr at the Z-Ditches and at the 216-T-26 Crib.

Subsurface Transport Over Multiple Phases (STOMP) modeling indicates that three of the five representative sites (216-U-10 Pond, 216-U-14 Ditch, and 216-T-26 Crib) are predicted to require groundwater protection. The STOMP model is used to predict whether existing radiological and nonradiological concentrations in soil would migrate to groundwater and result in groundwater concentrations that exceed federal maximum contaminant levels. These levels are defined as the average annual activity of beta particles and photon radioactivity from manmade radionuclides in drinking water that produces an annual dose equivalent to the total body or any internal organ of greater than 4 mrem/yr (40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides").

As summarized in Table 2-3, concentrations of nonradiological constituents at the 216-U-10 Pond and 216-A-25 Pond exceed wildlife screening values presented in WAC 173-340-900, Table 749-3. Similarly, concentrations of radiological constituents at all of the representative sites except for the 216-T-26 Crib exceed biota concentration guide values (DOE-STD-1153-2002). However, as discussed in Section 2.7, given site-specific conditions (e.g., available habitat and site size) only the 216-U-10 Pond and the 216-A-25 Pond pose potential ecological risks to burrowing animals under existing conditions.

Because no remedial activities would take place under this alternative, action-specific ARARs would not be triggered. No location-specific ARARs have been identified for the waste sites.

6.2.1.3 Long-Term Effectiveness and Permanence

Long-Term Effectiveness and Permanence for Human Health. For all five representative sites and their associated analogous waste sites, except the 216-B-64 Retention Basin, the no-action alternative fails to provide long-term effectiveness and permanence for human health, because contaminants would remain on site at concentrations that are above the PRGs. For this reason, this alternative fails to meet this criterion under CERCLA.

Long-Term Effectiveness and Permanence for Groundwater. Contaminants are predicted to reach the groundwater at three of the five representative sites (216-U-10 Pond, 216-U-14 Ditch, and 216-T-26 Crib). Therefore, Alternative 1 does not provide long-term effectiveness for groundwater protection for those sites nor for their analogous sites, except the 216-B-64 Retention Basin.

Long-Term Effectiveness and Permanence for the Environment. Three representative sites, 216-U-14 Ditch, 216-Z-11 Ditch, and the 216-T-26 Crib, and the analogous 216-B-64 Retention Basin, meet the standard for protection of the environment in the 0 to 4.6 m (0 to 15 ft) below ground surface (bgs) zone. The other two representative sites, 216-U-10 Pond and 216-A-25 Pond, do not meet the standard for protection of the environment.

6.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur at all the waste sites in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER Directive 9200.4-17P, the

EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation processes, the EPA considers source control and performance monitoring to be fundamental components of the remedy. The no-action alternative does not use any source control or monitoring. Because of the concentrations of contaminants and the substantial length of time required for natural attenuation processes to meet PRGs, this alternative fails to meet this criterion under CERCLA.

6.2.1.5 Short-Term Effectiveness

No short-term risks to humans would be associated with the no-action alternative because remedial activities would not be conducted. Current risks to workers are not an issue because of protective soil covers and appropriate safety measures for work activities. Ecological risk currently exists at two representative sites (216-U-10 Pond and 216-A-25 Pond), and, therefore, this alternative fails to meet the criterion for short-term effectiveness at two of the representative sites. These risks would not be mitigated in the no-action alternative.

6.2.1.6 Implementability

The no-action alternative could be implemented immediately and would not present any technical problems. Radionuclides at all of the waste sites addressed by this FS are currently undergoing natural attenuation.

6.2.1.7 Cost

The no-action alternative would involve no cost.

6.2.2 Detailed Analysis of Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

Under this alternative, existing soil covers and/or caps would be maintained to provide protection from intrusion by human and/or biological receptors. Legal and physical barriers also would be used to prevent human access to the site. The existing soil covers and/or caps would break the pathway between human and ecological receptors and the contaminants. Groundwater monitoring is included in this alternative.

The following sections present a detailed analysis of Alternative 2 against the evaluation criteria. This analysis is summarized in Table 6-1.

6.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 would provide overall protection of human health and the environment for sites that show protection of groundwater and achieve human health and environmental protection within 500 years. Because the viability of institutional controls cannot be ensured past 500 years, this alternative fails to meet this criterion for sites with long-lived contaminants such as plutonium, technetium, and uranium, because the waste sites would have contamination that would not attenuate to acceptable levels within 500 years. Risk assessment details are contained in Chapter 2.0 and in Appendices C and E and are summarized in this section.

216-U-10 Pond and its Analogous Sites – All waste sites in this group exceed groundwater protection criteria and exceed human health direct-contact and ecological PRGs in the 0 to 4.6 m (0- to 15-ft) zone, based on the evaluation of the 216-U-10 Pond representative site. As such, this alternative is not protective of human health or the environment at the 216-U-10 Pond and its analogous site.

216-U-14 Ditch and its Analogous Sites – The 216-U-14 Ditch and its analogous sites exceed human health direct-contact PRGs in the 0 to 4.6 m (0- to 15-ft) zone, based on the evaluation of the 216-U-14 Ditch representative site. As such, this alternative is not protective of human health at the 216-U-14 Ditch and its analogous sites, except at the 207-U Retention Basin, currently being used as a collection and evaporation basin for storm water runoff. No loose surface contamination has been measured within the basin since 1997, and there is no reason to believe that contamination leaked out of this concrete structure. However, there is insufficient characterization data to conclusively prove that there was no leakage at the site.

216-Z-11 Ditch and its Analogous Sites – The 216-Z-11 Ditch and its analogous sites exceed human health direct-contact PRGs in the 0 to 4.6 m (0- to 15-ft) zone, based on the evaluation of the 216-Z-11 Ditch representative site. In addition, an intruder analysis was performed on three proximate Z-Ditches (216-Z-11, 216-Z-1D, and 216-Z-19), and it was found that the 216-Z-1D Ditch and the 216-Z-19 Ditch posed a threat to intruders (Appendix E). Because the Z-Ditches run close to each other and are sometimes difficult to distinguish one from the other (as reported in DOE/RL-2003-11), it is assumed that the 216-Z-11 Ditch and its analogous sites pose a threat to intruders. Because of the threats to human health direct-contact and to intruders, this alternative is not protective of human health at the 216-Z-11 Ditch and its analogous sites.

216-A-25 Pond and its Analogous Sites – The 216-A-25 Pond exceeds human health direct-contact PRGs in the 0 to 4.6 m (0- to 15-ft) zone. However, levels of radionuclides will decrease to acceptable levels within 150 years. The 216-A-25 Pond exceeds nonradiological ecological PRGs in the 0 to 4.6 m (0- to 15-ft) zone. As such, this alternative is not protective of human health or the environment at the 216-A-25 Pond. Alternative 2 is protective for the 207-A North Retention Basin analogous site. This site consists of a series of three Hypalon[1]-lined concrete basins. No leakage outside the basin assembly has been documented, and the basins are not controlled radiologically.

216-T-26 Crib and its Analogous Site – All waste sites in this group exceed groundwater protection criteria based on evaluation of the 216-T-26 Crib representative site. However, no contamination was present in the 4.6 m (15-ft) bgs zone. The sites have significant concentrations of radionuclides just below 4.6 m (15 ft). These radionuclides pose a risk to intruders above RAOs. These radionuclides will take 190 years to attenuate naturally to levels that would achieve PRGs for the protection of human intruders. As such, this alternative is not protective of human health or the environment for these waste sites.

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[1]Hypalon is a registered trademark of Dupont Dow Elastomers Limited Liability Company, Wilmington, Delaware.

6.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Under Alternative 2, ARARs would not be met at any of the five representative sites. Risk analysis (Chapter 2.0 and Table 2-6) shows that groundwater protection standards will be exceeded at the 216-U-10 Pond, 216-U-14 Ditch and the 216-T-26 Crib. Ecological protection standards are exceeded at the 216-U-10 Pond and the 216-A-25 Pond. At the 216-U-10 Pond, and the 216-Z-11 Ditch, human health direct-contract, PRGs will be exceeded past the 150-year active institutional control period. Thus, each representative site fails to comply with ARARs in at least one category.

For the 207-A-North Retention Basin, Alternative 2 will comply with all ARARs, as discussed in the previous section.

6.2.2.3 Long-Term Effectiveness and Permanence

Human Health

Alternative 2 would rely on natural attenuation (e.g., radioactive decay) to decrease contaminants until concentrations reached levels that would be protective of human health and the environment. As mentioned under Alternative 1, natural attenuation is a proven and acceptable technology. This alternative would incorporate the use of institutional controls to prevent inadvertent human and biological intrusion into the waste until contaminant concentrations reached acceptable levels. Institutional controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Although institutional controls generally are considered to be proven and acceptable technologies meant to prevent access to hazards, they may not be effective for the extended lengths of time needed to address the contaminants at the waste sites in the 200-CW-5 OU, 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU (i.e., hundreds to thousands of years). Institutional control and monitoring would be required for the entire time that contaminants exceed PRGs to be effective. Institutional controls are assumed to be lost after 500 years.

Table 2-3 summarizes risk assessments for the five representative sites and shows that in all cases except at the 216-A-25 Pond, human health risks remain past the period of active institutional control (150 years). In the case of the 216-Z-11 Ditch, human health direct-contact doses remain above 15 mrem/yr for more than 1,000 years. At the 216-U-10 Pond, 216-U-14 Ditch, and the 216-T-26 Crib, groundwater protection standards are exceeded for long-lived radionuclides, which will out-live the institutional control period. At the 216-A-25 Pond, only ecological PRGs are an issue after 150 years. While the radionuclides contributing to ecological risk (Cs-137 and Sr-90) will decay substantially during this timeframe, chemical contaminants that pose ecological risk (arsenic, barium, and selenium) will not decay, and after the institutional control period it may be expected that the existing cap will erode, exposing fauna to these contaminants.

216-U-10 Pond and its Analogous Sites – Under Alternative 2, chemicals and radionuclides would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites in the 0 to 4.6 m (0- to 15-ft) zone at concentrations that would result in potential direct-contact human health risk. The 216-U-10 Pond has contaminants that would remain past the assumed 150-year active institutional control period. Therefore, this alternative is not protective of human health in the long term.

216-U-14 Ditch and its Analogous Sites – Under Alternative 2, chemicals and radionuclides would remain in the vadose zone beneath the waste sites in the 0 to 4.6 m (0- to 15-ft) zone at concentrations above PRGs and thus would result in a potential threat to groundwater. Therefore, this alternative is not protective of human health in the long term.

216-Z-11 Ditch and its Analogous Sites – Under Alternative 2, radionuclides would remain in the waste sites in the 0 to 4.6 m (0- to 15-ft) zone. These concentrations would exceed the human health guidelines of 15 mrem/yr and an ELCR of greater than 1 x 10^{-4} for direct-contact human health. In addition, radionuclides would remain in the 216-Z-19 Ditches at concentrations that would result in potential risk to human intruders. These contaminants will remain beyond the assumed 150-year active institutional control period. Therefore, this alternative is not protective of human health in the long term.

216-A-25 Pond and its Analogous Site – Risk analysis shows no long-term risk to groundwater from the 216-A-25 Pond. However, under Alternative 2, radionuclides would remain in the 0 to 4.6 m (0- to 15-ft) zone at concentrations that would result in potential direct-contact human health risk. By the end of the 150 years, these radionuclides will have decayed to levels that are protective of human health. Ecological risk at the 216-A-25 Pond is from radiological and chemical contaminants; the radiological contaminants (Cs-137 and Sr-90) will have decayed to below PRGs by the end of 150 years; however, the chemical contaminants will require continued control. Therefore, this alternative is protective of human health in the long term.

216-T-26 Crib and its Analogous Sites – Under Alternative 2, chemicals and radionuclides in this group would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites at concentrations that would result in potential risk to human intruders. The 216-T-26 Crib does not meet the 15 mrem dose to the public nor the CERCLA risk range of a 10^{-4} to 10^{-6} ELCR under the intruder scenario. The representative site also has contaminants that would remain beyond the assumed 150-year active institutional control period. Intruders to these waste sites could be exposed to significant radiological doses past 190 years. Therefore, this alternative is not protective of human health in the long term.

Protection of Groundwater

216-U-10 Pond and its Analogous Sites – As demonstrated by the risk analysis, reported in Chapter 2.0, and summarized in Tables 2-3 and 2-6, the 216-U-10 Pond exceeds groundwater protection PRGs for cyanide, fluoride, total uranium, Se-79, Tc-99, and several uranium isotopes. This alternative is not protective of the groundwater for the 216-U-10 Pond.

216-U-14 Ditch and its Analogous Sites – As demonstrated by the risk analysis, reported in Chapter 2.0, and summarized in Tables 2-3 and 2-6, the 216-U-14 Ditch exceeds groundwater protection PRGs for Tc-99 at 250 years and exceeds MCL at 470 years. In addition, several uranium isotopes reach groundwater at 800 years and continue to increase after 1,000 years. This alternative is not protective of the groundwater for the 216-U-14 Ditch.

216-Z-11 Ditch and its Analogous Sites – Risk analysis shows no long-term risk to groundwater from the 216-Z-11 Ditch. Therefore, Alternative 2 would be protective of groundwater at this site.

216-A-25 Pond and its Analogous Site – Risk analysis shows no long-term risk to groundwater from the 216-A-25 Pond. Therefore, Alternative 2 would be protective of groundwater at this site.

216-T-26 Crib and its Analogous Sites – As demonstrated by the risk analysis, reported in Chapter 2.0 and summarized in Table 2-6, the 216-T-26 Crib exceeds groundwater protection PRGs for cyanide, nitrate, nitrite, Tc-99, and several uranium isotopes. This alternative is not protective of the groundwater for the 216-T-26 Crib.

The Environment

Only two of the representative sites (216-U-10 Pond and 216-A-25 Pond) have contaminants located in the shallow soils (0 to 4.6 m [0- to 15-ft] bgs) that present potential risks to burrowing animals. In both cases, the risk to burrowing animals is reduced to acceptable levels shortly after the 150-year active institutional control period. Therefore, this alternative provides long-term protection to the environment for these sites.

6.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 does not provide any engineered treatment to reduce toxicity, mobility, or volume. However, natural attenuation will occur through radioactive decay.

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

This alternative provides a reduction in the mass of radioactive contaminants at each site. All five representative sites are within acceptable dose and risk guidelines for the 150-year active institutional control period with existing soil cover. With out the existing soil cover, the 216-Z-11 Ditch representative site exceeds acceptable dose and risk guidelines for the 150-year active institutional control period and at the end of a 500-year institutional control period. The remaining representative sites are within acceptable dose and risk guidelines for the 500-year institutional control period, with the exception of the 216-U-10 Pond. This site reaches an acceptable dose (14 mrem/yr) within 300 years and is very close to the ELCR range of $1x10^{-4}$-10^{-6} (1.2 x 10^{-4}) within the 500-year institutional control period. Also, Alternative 2 does not provide a method to limit infiltration into three of the representative sites (216-U-10 Pond, 216-U-14 Ditch and 216-T-26 Crib). These sites have mobile contaminants that are predicted to reach the groundwater. At the other two representative sites (216-Z-11 Ditch and 216-A-25 Gable Mountain Pond), there are no mobile contaminants of concern.

6.2.2.5 Short-Term Effectiveness

6.2.2.5.1 Remediation Worker Risk

For Alternative 2, only minimal short-term worker risks are expected, and these risks are associated with monitoring and maintenance activities. Experienced workers using appropriate safety precautions would conduct these activities. Risks would decrease over time as the radionuclides decay. As such, the risk to workers is qualitatively identified as low. Additionally, DOE control of the Central Plateau is assumed for the next 50 years given DOE's commitment to vitrify the waste in the tank farms. Therefore, failure of this alternative in the short term is considered unlikely.

6.2.2.5.2 Impact to Environment during Remediation

This alternative reduces the risk to human and ecological receptors through the use of existing soil covers and the implementation of institutional controls. Currently, all representative sites except the 216-T-26 Crib have contamination within the shallow soils 0 to 4.6 m (0 to 15 ft). As such, short-term impacts to vegetation and wildlife may occur at these sites during the implementation of this alternative. The waste sites have been highly disturbed, and the existing soil cover provides protection for all but the deeply rooted plants or deep-burrowing animals. The short-term impacts to the environment are expected to be low.

6.2.2.5.3 Time to Meet the Remedial Action Objectives

In this alternative, RAOs can only be fully met through natural radiological decay of contaminants, which can take hundreds to thousands of years to achieve. Therefore, this alternative does not meet RAOs in a reasonable time frame except for two analogous sites (207-U Retention Basin and 207-A North Retention Basin), discussed earlier.

6.2.2.6 Implementability

Alternative 2 could be readily implemented and would not present technical problems. This alternative currently is being implemented through Hanford Site access controls, surface and subsurface radiation area work and access controls, and the waste site/radiation area surveillance and maintenance program.

6.2.2.7 Cost

Cost estimates for Alternative 2 were developed based on existing costs for similar activities currently conducted on the Hanford Site. Details of the cost estimates are presented in Appendix D. Summarized costs for the representative and analogous sites are presented in Table 6-1. The input parameters used in these estimates are the best available at this time, but in many cases the data on contaminants of concern, site locations, and site dimensions are limited. The uncertainties identified above are similar for all the sites evaluated in this FS. Despite these uncertainties, the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives.

This alternative involves costs for activities similar to current activities. These involve periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, or other activities to control deep-rooted plants; control of deep burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; and site reviews. The present-worth costs assume a 3.2 percent discount rate (based on 2003 Office of Management and Budget information) and assumes an operation and maintenance period equal to the time required for PRGs to be met. Long-term monitoring costs associated with groundwater are not included in this cost estimate, because contaminated groundwater in the 200 East Area will be addressed by the 200-BP-5 and 200-PO-1 groundwater OUs, and contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 OUs.

6.2.3 Detailed Analysis of Alternative 3 – Removal, Treatment, and Disposal

Under Alternative 3, contaminated soil and debris (such as concrete or wood associated with cribs) would be removed, treated as necessary to meet disposal facility waste acceptance criteria, and transported for disposal at an approved waste disposal facility. Soils would be removed to meet PRGs. Alternative 3 has two disposal paths: one for disposal of soils contaminated with transuranic constituents above 100 nCi/g and one for disposal of soils that are not contaminated above these levels or that do not have transuranic constituents. These latter soils would be disposed on-site at the Environmental Restoration Disposal Facility (ERDF). Soils are not anticipated to require treatment before disposal at the ERDF, based on the data collected for the representative and analogous waste sites. Alternative 3 would remove contaminated waste and soil from waste sites to a depth to meet the RAOs.

One of the representative sites, the 216-Z-11 Ditch, was found to have concentrations of Pu-239/240 above 100 nCi/g. The maximum concentration of Pu-239/240 found at this site was 780 nCi/g. The amount of plutonium that the site received during its operation is unknown. Excavated soil that is determined to contain more than 100 nCi/g of transuranic constituents would be handled, packaged, stored, and ultimately disposed in accordance with ARARs. Disposal would likely occur at the Waste Isolation Pilot Plant (WIPP).

This alternative generally provides a high degree of overall protection of human health and the environment, because contaminants are removed to meet PRGs. Removal of the contaminants provides for the most flexibility for future land use.

This alternative would provide future protection to humans and the environment because the contaminants are removed from the waste site. The groundwater would be protected. Because contaminants above PRGs would be removed from a waste site and placed in an approved disposal facility, failure of this alternative is not likely. Residual risks would be at acceptable levels for protection of human health, the environment, and groundwater. Verification sampling would be conducted to determine that PRGs are met by the removal activities. Risks associated with the failure of the disposal facility are not evaluated here, but are evaluated as part of the permitting process for the facility.

Some of the representative sites have contamination greater than PRGs to depths near the water table. Excavation to these depths and levels of contamination is difficult, requires workers to be exposed to the high contaminant concentrations as well as risks associated with deep excavations, and has the potential to impact neighboring facilities, such as the tank farms. This type of excavation is expensive and creates considerable waste that requires disposal. Special excavation techniques, such as limited excavation lifts, and protection systems (e.g., equipment modifications, decontamination areas) likely would be necessary to support this alternative, which would significantly increase costs and disposal capacity (these are discussed in greater detail in the following subsections).

6.2.3.1 Overall Protection of Human Health and the Environment

Because this alternative removes contaminants that are above PRGs, it provides overall protection (human health and the environment) in all cases.

- **216-U-10 Pond** – Chemical and radiological contaminants in excess of the PRGs extend to a depth of at least 140 ft, the maximum depth of sampling. Because the effluent volume discharged to the pond exceeded the soil column pore volume, it is reasonable to assume that contamination extends to the water table at 210 ft. Excavating the site to this depth will provide overall protection of human health and the environment.

- **216-U-14 Ditch** – Risk analysis of the 216-U-14 Ditch shows that radionuclides would remain in the 0 to 4.6 m (0- to 15-ft) zone at concentrations above human health PRGs and would persist until approximately 300 years. As demonstrated by the risk analysis, the 216-U-14 Ditch exceeds groundwater protection PRGs for Tc-99; however, the Tc-99 of concern is still located within the 0 to 4.6 m (0- to 15-ft) zone. Therefore, excavating the site to 4.6 m (15 ft) will provide overall protection of human health and the environment.

- **216-Z-11 Ditch** – Risk analysis of the 216-Z-11 Ditch showed that contamination above PRGs occurs only in the shallow zone (0 to 4.6 m [0 to 15 ft]). The intruder analysis (Appendix E) was performed on three proximate Z-Ditches (216-Z-11, 216-Z-1D, and 216-Z-19), and it was found that at the 216-Z-1D Ditch and the 216-Z-19 Ditch, contaminants would have to be removed to a depth of 4.6 m (15 ft) to eliminate potential risk to intruders. Because the Z-Ditches run close to each other and are sometimes difficult to distinguish one from the other (as reported in DOE/RL-2003-11), it is assumed that the 216-Z-11 Ditch and its analogous sites would all have to be excavated to a depth of 4.6 m (15 ft) to ensure overall protection of human health and the environment.

- **216-A-25 Pond** – Risk analysis of the 216-A-25 Pond shows that the only risk to human health and the environment after the 150 years will be ecological risk from arsenic, barium, and selenium. Therefore, excavating the site to 4.6 m (15 ft) will provide overall protection of human health and the environment.

- **216-T-26 Crib** – The risk analysis for the 216-T-26 Crib found in DOE/RL-2003-64, *Feasibility Study for the 200-TW-1 Scavenged Waste Group, the 200-TW-2 Tank Waste*

Group, and the 200-PW-5 Fission-Product-Rich Waste Group Operable Units, shows that contaminants in excess of PRGs extend to a depth of 200 ft. Hence, excavation to this depth would be required in this alternative to ensure overall protection of human health and the environment.

6.2.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 would comply with chemical-specific ARARs by removing soil that exceeds the PRGs and by removing or abandoning structures. Removal of all contaminants would achieve the chemical-specific ARARs discussed in Section 6.2.1.2 for protection of human health, ecological receptors, and groundwater protection. Action-specific ARARs, such as worker, public, and environmental exposure standards, may be exceeded under this alternative during implementation unless proper precautions are taken. Other action-specific ARARs that could be pertinent to Alternative 3 are Washington State solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites), and Federal and state regulations related to air emissions. It is anticipated that these ARARs could be met. No location-specific ARARs have been identified for the waste sites addressed in this FS.

6.2.3.3 Long-Term Effectiveness and Permanence

Human Health

With regard to human health, this alternative would be effective and permanent in the long term for all sites because excavation activities under Alternative 3 would remove contaminants to meet human health RAOs. EPA and Ecology cleanup authorities prescribe remedies that use permanent solutions to the maximum extent practicable and where cost effective. Removal of contaminants would be a permanent solution at the waste sites; however, much of the waste would remain on site at the ERDF or be disposed of at the WIPP geologic repository.

The removal of buried materials from the Central Plateau, for disposal on the Hanford Site at the ERDF, transfers the long-term impact of buried waste from individual waste sites to one consolidated disposal facility. The ERDF is designed for long-term management of buried waste.

Protection of Groundwater

Contaminants are removed to meet the RAOs. Therefore, Alternative 3 meets this criterion.

The Environment

All contaminated soil in the 0 to 4.6 m (0- to 15-ft) bgs zone is removed in this alternative. Therefore, this alternative would be effective and permanent for all representative and analogous sites with respect to the environment. Excavation and transportation of waste and structures would disturb areas beyond the waste site boundaries during the implementation period. These areas would need to be revegetated after disturbance and would require activities to control intrusion by non-native, noxious plants. This should not adversely affect the alternative in the long term or permanently. Because of the large volumes of backfill material that would be needed to fill excavations in excess of 60 m (200 ft), borrow areas would be impacted. Some of the identified borrow areas are in potentially ecologically sensitive areas.

6.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

In general, the removal, treatment, and disposal alternative would include treatment to reduce toxicity, mobility, or volume. However, with the availability of the ERDF, treatment is not anticipated, nor is treatment anticipated for any waste planned for shipment to WIPP. Radiological decay ultimately results in reduction of toxicity and volume. Movement of the waste to the ERDF or to the WIPP would result in reduction of mobility. Both facilities would provide additional protection against remobilization of contaminants over their current location.

6.2.3.5 Short-Term Effectiveness

6.2.3.5.1 Remediation Worker Risk

The levels of contamination in many of the waste sites may pose a significant dose threat to workers. The levels of Cs-137 and Sr-90 and potentially other radionuclides (e.g., Am-241 and plutonium in the Z-Ditches) may result in excavation and disposal activities being identified as nuclear activities. In addition, the levels may result in implementing remote-handled removal techniques. Whether remote handled or contact handled, special safety controls will be required to address the contaminant concentrations. Shielded excavation equipment for these wastes will be required to reduce worker dose. Additional measures are needed to limit the quantity of exposed soil during excavation, such as a rolling excavation, where only a small portion of the waste site is excavated at a time. The excavation is backfilled before the next small section of the waste site is exposed. Worker protection also may include providing filtered breathing air and dust suppression. These activities limit the worker, risk but also have a direct impact on schedule and cost. Based on the effectiveness of such controls, construction of a containment structure to further limit airborne releases may be needed. Nonetheless, excavation with dust suppression and health and safety controls has been proven to be effective in excavating large soil sites. Worker dose calculations are contained in engineering files and summarized below for each representative site.

- **216-U-10 Pond** – The primary radionuclides of concern to remediation workers are Cs-137 and Co-60. Total cumulative radiation dose to all workers from implementing this alternative is estimated to be 1.4 rem.

- **216-U-14 Ditch** – The primary radionuclide of concern to remediation workers is Cs-137. Total cumulative radiation dose to all workers from implementing this alternative is estimated to be 0.02 rem.

- **216-Z-11 Ditch** – The primary radionuclide of concern to remediation workers is Am-241. Total cumulative radiation dose to all workers from implementing this alternative is estimated to be 5.8 rem.

- **216-A-25 Pond** – The primary radionuclide of concern to remediation workers is Cs-137. Total cumulative radiation dose to all workers from implementing this alternative is estimated to be 3.8 rem. Because the analogous site to the 216-A-25 Pond, the 207-A North Retention Basin, is much smaller than the 217-A-25 Pond and is assumed to have similar specific activity of radionuclides, the cumulative dose from remediation the 207-A North Retention Basin will be much smaller. Based on the ratio of contaminated volumes (Appendix D), the cumulative dose from remediation the 207-A North Retention Basin will be very small (approximately 2 mrem).

- **216-T-26 Crib** – The primary radionuclide of concern to remediation workers is Cs-137. Total cumulative radiation dose to all workers from implementing this alternative is estimated to be 0.6 rem.

6.2.3.5.2 Impact to Environment during Remediation

Physical disruption of the waste sites during excavation, increased human activity, and noise, in addition to the generation of fugitive dust, affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. Potential animal intrusion and biological uptake also are issues that will require control of open excavations and exposed contaminated soils at the end of each day. This control could be accomplished through placement of covers or fixatives. Not only are digging animals a concern, but in open trenches where cellulose was used to control dust and other airborne releases, insects such as fruit flies represent a further pathway to spread contamination. These are documented pathways at the Hanford Site. Areas of disturbed surface are documented in Appendix D and reported below. Additional disturbed area was estimated to average 20 percent of the site area.

- **216-U-10 Pond** – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 235 ha (580 a). A conservative assumption is that an additional 47 ha (116 a) will be disturbed from activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of 280 ha (700 a).

- **216-U-14 Ditch** – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 12 ha (30 a). It is assumed that an additional 2 ha (6 a) will be disturbed from activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of 14 ha (36 a).

- **216-Z-11 Ditch** – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 3 ha (7 a). It is assumed that an additional 0.6 ha (2 a) will be disturbed from activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of 4 ha (8 a).
- **216-A-25 Pond** – The surface area disturbed during excavation of this representative site and its analogous waste site (207-A North Retention Basin) will be 0.1 ha (0.3a) A slightly larger area will be impacted due to activities such as staging construction activities and stockpiling clean soil. The 216-A-25 Pond is not included, as impacts from remediation of this site are included in another FS.
- **216-T-26 Crib** – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 5 ha (13 a). It is assumed that an additional 1 ha (2 a) will be disturbed from activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of 6 ha (15 a). The 216-T-26 Pond is not included, as impacts from remediation of this site are included in another FS.

Alternative 3 may pose a significant short-term impact on the environment by disturbing areas of recovering habitat, such as the 216-A-25 Gable Mountain Pond, where grasses are becoming more prevalent. While the deeper-rooted plants currently are controlled, the grasses do provide more habitat than unvegetated areas. Additionally, the disruptive nature of the removal process can have impacts on neighboring habitats and visiting wildlife, such as birds.

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to the ERDF and WIPP, and bringing clean fill to the excavated sites. Because the ERDF is located onsite, minimal uncertainties are associated with the transport of waste. Excavated soils with transuranic constituents above 100 nCi/g would be analyzed; treated, if necessary; and transported to the WIPP. The only waste currently identified in this FS as potentially requiring disposal to WIPP (e.g., greater than 100 nCi/g) is 2064 m^3 (2,700 yd^3) of soil beneath the 216-Z-11 Ditch and soil below the analogous Z-Ditches. When excavated, this soil must be placed in containers, certified, and transported to the WIPP. These actions would cause short-term impacts, generating approximately 10,900 55-gal drums requiring transport to and disposal at the WIPP. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., waste or fill-material particulates) that could affect the public and the environment.

6.2.3.5.3 Time to Achieve the Remedial Action Objectives

This alternative prevents the risk to human or ecological receptors by moving the source to an engineered disposal facility. Construction and waste excavation activities would be expected to require several months to many years to complete. Once completed, all long-term RAOs will be met (reducing risk to human health and ecological receptors, protection of groundwater, and reduction of exposure to industrial workers). The only RAOs not met are short-term concerns: preventing or reducing occupational health risks and minimizing the general disruption of wildlife habitat. The issue of disruption of wildlife habitat is mitigated due to current and future land use. These waste sites are located in an industrial setting providing little habitation for vegetation and wildlife. The following estimates of time to complete remediation activities under Alternative 3 are from Appendix D. The extremely long timeframe for some waste groups are due to very conservative assumptions used in Appendix D, including the assumption that only two hydraulic excavators are used, operations are conducted 40 hours per week, and ERDF only can accept 336 m^3(440 yd^3) of waste per day.

- **216-U-10 Pond** – Remediation of this representative site would take approximately 130 years. If analogous sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, and using the conservative assumptions discussed above, the time to remediate the analogous sites would be an additional 715 years, for a total of 845 years.

- **216-U-14 Ditch** – Construction of the removal, treatment, and disposal alternative for this representative site would take approximately 0.6 years. If analogous sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, and using the conservative assumptions discussed above, the time to remediate the analogous sites would be an additional 3.3 years, for a total of 3.9 years.

- **216-Z-11 Ditch** – Remediation of this waste site group would take approximately 1.5 years.

- **216-A-25 Pond** – Remediation of this representative site would take approximately 11 years. However, the remediation impacts for the representative site are included in another feasibility study. The time to remediate 207-A North Retention Basin would be approximately 6-months after the notice to proceed.

- **216-T-26 Crib** – Remediation of the 216-T-26 Crib analogous waste sites would take approximately 8.4 years. The 216-T-26 Pond is not included, as impacts from remediation of this site are included in another FS

6.2.3.6 Implementability

Excavation is a proven and implementable technology used to remove wastes. Deeper excavations will require the use of more sophisticated digging equipment and techniques, the use of approach ramps and shoring, extensive removal of clean material to obtain adequately safe side slopes, etc. The aboveground structures (e.g., vent pipes and concrete structures) would be removed along with the waste site soil covers and contaminated soils. Every 0.3 m (1 ft) of excavation would required 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated, but is considered implementable.

Depending on the location and excavation depth, the size of excavation for some sites may interfere with unrelated buildings, roads, utilities, other waste sites, and tank farms.

216-U-10 Pond and its Analogous Sites – To remove soils above the PRGs, the excavation would be advanced to a depth of 64 m (210 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. To remove the contaminants of concern at this group, 31 million m^3 (41 million yd^3) of soil would have to be removed and sent to ERDF. The remaining capacity of ERDF in February 2004 was 5.9 million m^3 (7.7 million yd^3), so implementing this alternative for this group of waste sites will require expansion of the ERDF. Four of the 216-U-10 Pond analogous sites are concrete control structures, and for estimating purposes it was assumed that these sites only were excavated to a depth of 4.6 m (15 ft).

216-U-14 Ditch and its Analogous Sites – To remove soils above the PRGs, the excavation would be advanced to a depth of 4.6 m (15 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. To remove the contaminants of concern at this group, 49,000 m^3 (64,000 yd^3) of soil would have to be removed and sent to ERDF.

216-Z-11 Ditch and its Analogous Sites – To remove soils above the PRGs, the excavation would be advanced to a depth of 4.6 m (15 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. To remove the contaminants of concern at this group, 28,000 m^3 (36,000 yd^3) of soil would have to be removed and sent to ERDF and WIPP. The volume that would go to WIPP would be determined by onsite sampling during the excavation and packaging process. The estimated quantity of potential contaminated soil is not explicitly defined. This issue may require additional discussions with the operators of the WIPP facility, which is an open implementability issue.

216-A-25 Pond and its Analogous Site – To remove soils above the PRGs, the excavation would be advanced to a depth of 4.6 m (15 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. To remove the contaminants of concern at waste site 207-A Retention Basin, 660 m^3 (860 yd^3) of soil would have to be removed and sent to ERDF.

216-T-26 Crib and its Analogous Sites – To remove soils above the PRGs, the excavation would be advanced to a depth of 61 m (200 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated. To remove the contaminants of concern at the 216-T-26 Crib analogous sites, 10,200 m^3 (13,300 yd^3) of soil would have to be removed and sent to ERDF.

Coordination with other agencies and local governments would be necessary after approval of the alternative. Excavation and disposal would require coordination with state agencies to assess matters relative to storm water control and the potential for radioactive air emissions.

The current remaining capacity of ERDF is 7.65 million m^3 (as of February 6, 2004). Approximately 31 million m^3 (41 million yd^3) of soils would be sent to the ERDF if Alternative 3 were to be chosen for all waste sites addressed by this FS. The majority of the volume would result from excavation of the 216-U-10 Pond and its analogous sites. Representative sites 216-A-25 and 216-T-26 are not included in this volume estimate because these sites are addressed in FSs conducted for the 200-CW-1 and 200-TW-1 OUs; however, their analogous sites are included within this estimate. The disposal volume for all sites is 31,079,828 m^3 (40,651,139 yd^3), the current capacity of ERDF.

6.2.3.7 Cost

Costs include mobilizing personnel and equipment; monitoring, sampling, and analysis; excavating; disposing of the waste at the ERDF and WIPP; backfilling with onsite resources and additional backfilling from a local stockpile; revegetating; and performing prime contractor oversight.

Costs are based on the use of standard excavation equipment (e.g., hydraulic excavators, front-end loaders, tractor trailers). The costs are based on the assumption that a subcontractor would do the work, with oversight performed by prime contractor personnel. Details of the cost estimates are presented in Appendix D. Summarized costs for the representative and analogous sites are presented in Table 6-2. The programmatic disposal cost at WIPP are not included in the cost estimate. The average programmatic disposal cost assigned to Hanford for fiscal years 05 and 06 average $31,366 per cubic meter per year ($23,980 per cubic yard per year). If this cost were added to the project disposal cost the total disposal, cost for this alternative would be $142,247,147.

6.2.4 Detailed Analysis of Alternative 4 – Capping

The following sections present a detailed analysis of Alternative 4 against the evaluation criteria. This analysis is summarized in Table 6-3. Two types of caps were analyzed for this alternative. A Modified RCRA C barrier was analyzed for all of the waste sites except the 216-Z-11 Ditch. Because high concentrations of transuranics are present at the 216-Z-11 Ditch, the Hanford Barrier was analyzed for this representative site.

6.2.4.1 Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment because the capping system would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion. The cap would be sufficiently robust to account for the types and levels of contamination in the waste sites. A capping system would provide additional distance between potential human and ecological receptors, above and beyond the existing soil covers over the waste sites. Additionally, the capping system would include a layer that would limit unwanted intrusion, along with institutional controls such as monitoring, and provide a warning to potential intruders and notification of land-use restrictions.

Institutional controls, including maintenance of the cap, use restrictions, and monitoring, would be instituted at capped sites until the PRGs are achieved through natural attenuation. Institutional controls would provide additional protection against human intrusion and would provide for groundwater monitoring as a means of identifying impacts to groundwater. Groundwater monitoring would be coordinated with monitoring at the appropriate groundwater OU.

The cap would be designed to address potential failure of the institutional controls and would provide additional intrusion protection past the 500-year period and infiltration control to protect groundwater. Integrity of the Hanford Barrier past a 1,000-year period is uncertain. However, the Hanford Barrier meets the performance criteria of in 10 CFR 61.41 and 10 CFR 61.42. At the other four representative sites, Alternative 4 would be protective because contaminants are expected to attenuate within the service life of a Modified RCRA C barrier (500 years).

6.2.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all ARARs for the waste sites by breaking the pathways for exposure and emplacing caps that meet the intent of the regulations. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative.

6.2.4.3 Long-Term Effectiveness and Permanence

Human Health

The capping alternative would be protective of human health and the environment by breaking exposure pathways. Chemicals and radionuclides left in place at the waste sites would be physically separated from receptors by the thickness of the cap and by the additional thickness of the existing soil covers. Intrusion layers in the caps would help protect against inadvertent intruders, along with institutional controls such as markers and use restrictions. Because contaminants at the waste sites have the potential to impact groundwater, caps would be designed to limit and control infiltration.

Caps can fail over time, especially if not properly maintained. The modified RCRA C cap has a design life of 500 years; therefore, the cap likely would not require replacement for four of the representative waste sites because PRGs are reached before the end of the 500-year design life. TRU[1] contamination at the 216-Z-11 Ditch is anticipated to take more than 1,000 years to attenuate. The Hanford Barrier is designed for 1,000 years and would provide additional protection and design life compared to a modified RCRA C cap. A surface barrier such as the Hanford Barrier is proposed for Alternative 4 at the 216-Z-11 Ditch. Alternative 4 would be effective and permanent for the other four representative and its analogous sites.

Because a significant amount of risk attenuates within the active institutional controls period for sites with significant risk contribution from short-lived radioisotopes (all sites except the Z-Ditches), failure of the caps in later years would be associated with lower risks than at present. Additionally, the 5-year reviews required for sites with contaminants above PRGs would serve to monitor the effectiveness and reliability of the caps; adjustments and maintenance activities could be instituted to help prevent failure, based on the 5-year review results.

The long-term effectiveness depends on the proper construction and maintenance of the barrier and associated institutional controls throughout the natural attenuation time frame to prevent

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[1]Waste materials contaminated with 100 nCi/g of transuranic materials having half-lives longer than 20 years.

exposure to potential receptors. Maintenance activities would include erosion repairs and possible vegetation maintenance. Subsidence is not considered to be a major factor in maintenance activities for these waste sites. Failure of the cap is unlikely if maintenance and institutional control activities continue. The assumption used is that institutional controls past 500 years or so would not necessarily be maintained and could fail. Caps would be designed and constructed to account for the necessary time frame to reach PRGs and to minimize maintenance requirements and impacts from institutional controls failure.

In addition, management controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Once remediated, the barrier and surrounding disturbed area would be revegetated to further enhance evapotranspiration, limit erosion, and blend the site area into the surrounding landscape.

216-U-10 Pond – The dominant short-lived contaminant of concern (Cs-137) for human health direct-contact industrial dose at this representative site will reach PRGs in 280 years (Table 2-6). There is no intruder risk at this site. Therefore, a 500-year cap would be adequate to protect the industrial user. A groundwater protection cap will be needed to address chemical and radiological contaminants listed in Table 2-3.

216-U-14 Ditch – The dominant short-lived contaminant of concern (Cs-137) for human health direct-contact industrial dose at this representative site will reach PRGs in 210 years (Table 2-6). There is no intruder risk at this site. Therefore, a 500-year cap would be adequate to protect the industrial user. A groundwater protection cap will be needed to address radiological contaminants listed in Table 2-3.

216-Z-11 Ditch – Contaminants of concern for the representative site include transuranic constituents above 100 nCi/g. The dominant contaminant of concern (Pu-239) for human health direct-contact industrial dose and intruder dose at this representative site will reach PRGs in more than 1,000 years. Therefore, a 1,000-year cap, a barrier type such as a Hanford Barrier, will be required. In addition, this cap is protective of groundwater, although no groundwater risk has been identified at this site.

216-A-25 Pond – The dominant short-lived contaminant of concern (Cs-137) for human health direct-contact industrial dose at this representative site will reach PRGs at approximately 150 years. There is no intruder risk at this site. Therefore, a cap would not be necessary to prevent human exposure after the institutional control period. However, ecological PRGs will be exceeded beyond 150 years, so a cap will be required to protect ecological receptors. A groundwater protection cap will not be required, because contaminants do not exceed groundwater protection PRGs.

216-T-26 Crib – The dominant short-lived contaminant of concern (Cs-137) for human health direct-contact dose at this representative site does not exceed PRGs and will reach PRGs for intruder risk in approximately 190 years (Appendix E). Therefore, a 500-year cap will be adequate to protect the inadvertent intruder. A groundwater protection cap will be needed to address chemical and radiological contaminants listed in Table 2-3.

Protection of Groundwater

This alternative is protective of the groundwater because it limits infiltration at the waste site. The caps form a protective barrier from precipitation and intruder risk until RAOs are met. Additionally, the 5-year review would focus on groundwater protection monitoring and effectiveness of the cap in addressing the mobile contaminants at depth (e.g., Tc-99, nitrates).

The Environment

This alternative would provide protection to the environment by placing a barrier between the waste and the surface flora and fauna. As previously mentioned, only two representative sites (216-U-10 Pond and 216-A-25 Pond) fail the protection of the environment from an ecological perspective. At these two sites, the caps would be designed to prevent the intrusion of deep-rooted flora and burrowing fauna.

6.2.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation. The capping alternative would rely on natural attenuation processes (most importantly radioactive decay) to reduce radioactivity to levels that would not present a risk to human health or the environment. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require extended periods for radionuclides to decay to PRG levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

The capping alternative would address the mobility of contaminants by limiting infiltration to the vadose zone, thereby limiting the driving force to move contaminants to the groundwater.

6.2.4.5 Short-Term Effectiveness

6.2.4.5.1 Remediation Worker Risk

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 4, only moderate short-term risks are expected. The capping alternative would not require excavation of contaminated soils, so the risks to workers primarily would be associated with general construction activities at the borrow sites and placement of the cap. If structures were removed, workers could be exposed to potentially contaminated debris. Worker risk would be controlled through adherence to site health and safety procedures. Air monitoring would address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers.

6.2.4.5.2 Impact to Environment during Remediation

Physical disruption of the waste sites during cap construction, increased human activity and noise, and the generation of fugitive dust affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. As such, short-term impacts to vegetation and animals at these sites would be low because these sites currently are poor wildlife habitats; however, Cs-137 and Sr-90 have low-screening levels for biota, and exposure during remediation could be at unacceptable levels if controls were not in place to limit access.

Construction activities at the waste sites could disrupt wildlife in the area because of increased noise and human activity. However, most of the waste sites are located in areas already disturbed by earlier facility operations and in areas adjacent to ongoing facility operations, so impacts on biological resources would be low.

6.2.4.5.3 Time to Meet the Remedial Action Objectives

The following estimates of time to complete remediation activities under Alternative 4 are from Appendix D. Appendix D calculated time to complete remediation for the representative sites only; time to complete remediation for the analogous sites was calculated by using the cap surface areas ratio. This technique may overestimate time to complete remediation for the entire waste group, since operations may proceed concurrently rather than consecutively.

- **216-U-10 Pond** – Design and construction of the cap for this waste group would take approximately 6.7 years.

- **216-U-14 Ditch** -- Design and construction of the cap for this waste group would take approximately 9.6 years.

- **216-Z-11 Ditch** -- Design and construction of the cap for this waste group would take approximately 2.3 years.

- **216-A-25 Pond** -- Design and construction time for the 216-A-25 Pond is not included, as this was accounted for in another Feasibility Study. Design and construction time for analogous site 207-A-North Retention Basin was not calculated in Appendix D. However, because the site is very small (0.1 ha (0.2 acre)), design and construction time will not take more than a few months.

- **216-T-26 Crib** -- Design and construction of the cap for 216-T-26 Crib analogous waste sites would take approximately 3.6 months. Design and construction time for the 216-T-26 Crib is not included, as this was accounted for in another Feasibility Study.

6.2.4.6 Implementability

The capping alternative is considered implementable at all waste sites. A prototype Hanford Barrier has been implemented at the Hanford Site at the 216-B-57 Crib (CP-14873, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2002)*. Other types of barriers (including the modified RCRA C cap) have not been used at the Hanford Site, but have been implemented at other sites and are easy to construct and maintain. The existing soil covers over the waste sites would be considered a part of the overall design to minimize the cost of materials and to minimize the impact to visual aesthetics.

Construction of the caps would follow standard procedures that have been thoroughly field tested. The caps likely would require minor repair and possibly replacement during the restoration time frame. Monitoring the continued integrity of the caps would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the capping alternative would require additional design data (e.g., ground-penetrating radar) and possibly confirmatory sampling, because existing data may not be adequate for determining the lateral extent of the caps.

Gravel, sand, and silt/loam soil used for the caps would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix D. Area C currently is being evaluated as a silt borrow location; the area has a large volume of fine-grained material. Other locations have not yet been determined. Soil most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas. Analyses of an appropriate borrow area for silt/loam soil would be the subject of a future NEPA evaluation to determine a location with the least impacts to natural and cultural resources. Borrow material occurs in environmentally sensitive areas; obtaining sufficient capping material, especially for a multilayered cap, would affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the cap. Materials such as rip-rap that may be used in the cap construction could be obtained on the Hanford Site or could be purchased from local dealers.

Capping materials hauled to the Central Plateau from borrow areas and gravel pits within the Hanford Site would increase heavy equipment use and transportation activities at the sites. However, radioactive or hazardous waste would not have to be hauled from the Site.

6.2.4.7 Cost

Costs, shown in Table 6-3, include stabilization of the existing site; excavation or import, transportation, and placement of capping material; compaction of the cap; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.2 percent discount rate (based on 2003 Office of Management and Budget information) and assume operations and maintenance for 150 years. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. Long-term monitoring costs associated with groundwater are not included within this cost estimate because contaminated groundwater in the 200 East Area will be addressed by the 200-BP-5 and 200-PO-1 groundwater OUs, and contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 OUs.

6.2.5 Detailed Analysis of Alternative 5 – Partial Removal, Treatment, and Disposal with Capping

This alternative includes the removal of contaminants extending to depths shown in Table 5-2. The excavation would be filled with borrow material obtained on the Hanford Site. When the backfilling operation is finished, the site would be capped. These activities remove a significant fraction of the near-surface contaminant load and still provide protection to the groundwater from deeper contaminants that are impracticable to remove. The removal, treatment, disposal, and capping activities would be the same as those described earlier. This alternative is not applicable to sites where contamination is shallow with no deep component or where contamination is very deep with no shallow component.

6.2.5.1 Overall Protection of Human Health and the Environment

This alternative would break potential exposure pathways to receptors through placement of a cap to limit infiltration. The cap would provide additional distance between potential human and ecological receptors. The partial removal activity would remove the high contamination zone at the bottom of the waste site, leaving only the lower concentration, deeper contaminants that mainly pose a risk to groundwater. Partial removal of the more shallow contamination would reduce human health and ecological risk for those sites where contamination is in the 0 to 4.6 m (0- to 15-ft) bgs zone and intruder risk associated with the high concentrations at the bottom of the waste site (see Appendix E). While, in the long term, this alternative is protective of human health and the environment, the radiological risk to workers during the excavation essentially is the same as for Alternative 3, because the material being removed under Alternative 5 is the same material that causes most of the dose for the full-excavation alternative.

Institutional controls, including maintenance of the cap, land-use restrictions, and monitoring, would be instituted at capped sites until the RAOs are achieved through natural attenuation. The cap would be designed to maximally limit infiltration. Institutional controls would provide additional protection for groundwater monitoring by providing a means to identify potential impacts to groundwater.

216-U-10 Pond – The 216-U-10 Pond and analogous sites are candidates for this alternative. Although risk analysis for the 216-U-10 Pond showed no risk from the intruder scenario, human health direct-contact PRGs are exceeded in the shallow zone (0 to 4.6 m [0 to 15 ft]), and groundwater protection PRGs are exceeded in the deeper zone.

216-U-14 Ditch – The 216-U-14 Ditch and analogous sites are not candidates for this alternative. Risk analysis for the 216-U-14 Ditch showed that human health direct-contact PRGs are exceeded in the shallow zone (0 to 4.6 m [0 to 15 ft]). However, groundwater protection PRGs are not exceeded in the deeper zone. Therefore, once the site is excavated to 4.6 m (15 ft), there is no need for a cap, and these sites are not candidates for this alternative.

216-Z-11 Ditch – Risk analysis of the 216-Z-11 Ditch showed that contamination above PRGs occurs only in the shallow zone (0 to 4.6 m [0 to 15 ft]). The intruder analysis (Appendix E) was performed on three proximate Z-Ditches (216-Z-11, 216-Z-1D, and 216-Z-19), and it was found that at the 216-Z-1D Ditch and the 216-Z-19 Ditch, contaminants would have to be removed to a depth of 4.6 m (15 ft) to eliminate potential risk to intruders. Because the Z-Ditches run close to each other and are sometimes difficult to distinguish one from the other (as reported in DOE/RL-2003-11), it is assumed that the 216-Z-11 Ditch and its analogous sites would all have to be excavated to a depth of 4.6 m (15 ft) to ensure overall protection of human health and the environment. However, after removal of contamination to the 4.6 m (15-ft) depth, site RAOs will be met. Therefore, these sites are not candidates for this alternative.

216-A-25 Pond – Risk analysis of the 216-A-25 Pond showed that contamination above PRGs occurs only in the shallow zone (0 to 4.6 m [0 to 15 ft]). After removal of contamination to the 4.6 m (15-ft) depth, site RAOs will be met. Therefore, the 216-A-25 Pond and its analogous site are not candidates for this alternative.

216-T-26 Crib – The 216-T-26 Crib contains contaminants to a depth of 9.1 m (30 ft) that present a risk to intruders and contains contamination in deeper zones that are a threat to groundwater. Therefore, the 216-T-26 Crib and its analogous sites are candidates for Alternative 5.

6.2.5.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 5 would comply with ARARs for the waste sites by breaking the pathways for exposure and emplacing caps that meet the intent of the groundwater protection regulations. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative.

6.2.5.3 Long-Term Effectiveness and Permanence

Human Health

With regard to human health, this alternative would be effective and permanent in the long term because excavation activities under Alternative 5 would remove contaminants to meet direct exposure human health and intruder RAOs, and placement of a cap would limit infiltration of water to the vadose zone. EPA and Ecology cleanup authorities prescribe remedies that use permanent solutions to the maximum extent practicable and where cost effective. Removal of contaminants would be a permanent solution. This action would remove any potential human or ecological direct-contact exposure.

Under this alternative, the most highly contaminated soils would be removed and disposed at either the ERDF or the WIPP. The removal of buried materials from the Central Plateau, for disposal on the Hanford Site at the ERDF, transfers the long-term impact of buried waste from individual waste sites to one consolidated disposal facility. The ERDF is designed for long-term management of buried waste.

216-U-10 Pond and its Analogous Sites – This alternative will remove contaminants in the shallow zone (to 4.6 m [15 ft]), thereby eliminating long-term human health direct-contact and ecological risk. No long-term intruder risks were identified from the risk analysis in Appendix E. Groundwater protection PRGs are exceeded at this site, and placement of a cap will limit infiltration and therefore will protect groundwater for the duration of the cap.

216-U-14 Ditch and its Analogous Sites – This alternative would remove contaminants in the shallow zone (to 4.6 m [15 ft]), thereby eliminating long-term human health direct-contact risk. No long-term intruder risks were identified from the risk analysis in Appendix E. Although groundwater protection PRGs are exceeded, contaminants currently reside in the shallow zone. Therefore, once the site is excavated to 4.6 m (15 ft), there is no need for a cap, and these sites are not candidates for this alternative.

216-Z-11 Ditch and its Analogous Sites – The 216-Z-11 Ditch and its analogous sites are assumed to exceed human health direct-contact PRGs in the 0 to 4.6 m (0- to 15-ft) zone, based on the evaluation of the 216-Z-11 Ditch representative site. In addition, an intruder analysis was performed on three proximate Z-Ditches (216-Z-11, 216-Z-1D, and 216-Z-19), and it was found that all three ditches pose a threat to intruders (Appendix E). This alternative would remove contaminants in the shallow zone (to 4.6 m [15 ft]), thereby eliminating long-term human health direct-contact and intruder risk. Groundwater protection PRGs are not exceeded at this site. Therefore, after removal of contamination to the 4.6 m (15-ft) depth, long-term human health risks will be eliminated, and these sites are not candidates for this alternative.

216-A-25 Pond and its Analogous Site – This alternative will remove contaminants in the shallow zone (to 4.6 m [15 ft]), thereby eliminating long-term human health direct-contact risk. No long-term intruder risks were identified from the risk analysis in Appendix E. Groundwater protection PRGs are not exceeded at this site. Therefore, after removal of contamination to the 4.6 m (15-ft) depth, long-term human health risks will be eliminated, and these sites are not candidates for this alternative.

216-T-26 Crib and its Analogous Sites – This site has contamination that would remain beyond the assumed 150 years of active institutional controls and would pose a risk to intruders. Partial removal of the contamination to 9.1 m (30 ft) would reduce the intruder dose to less than 15 mrem/yr. Groundwater protection PRGs are exceeded at this site, and placement of a cap would provide protection for groundwater for the duration of the cap.

Protection of Groundwater

Alternative 5 would protect groundwater through placement of a cap that would limit infiltration. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are protective elements of this alternative.

The Environment

All contaminated soil in the 0 to 4.6 m (0- to 15-ft) bgs zone is removed in this alternative. Therefore, this alternative provides long-term protection to the environment following implementation.

6.2.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The partial removal, treatment, and disposal with capping alternative would address the mobility of contaminants by removing a portion of the contaminates and limiting infiltration to the vadose zone, thereby limiting the mass and driving force to move contaminants to the groundwater. Natural attenuation is an important treatment component of this alternative that results in the reduction of toxicity, mobility, and volume of the radionuclides. Movement of the waste to the ERDF will result in a perceived reduction of mobility, because ERDF is a potentially less mobile environment that includes monitoring.

6.2.5.5 Short-Term Effectiveness

6.2.5.5.1 Remediation Worker Risk

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. Short-term effects of this alternative would be associated primarily with worker safety during waste excavation (soil and structures), transportation, and disposal. Unprotected workers present an unacceptable risk because of the concentrations and nature of the contaminants at the waste sites. The major contaminants in most of the waste sites are short-lived radionuclides (Cs-137 and Sr-90) that emit relatively high radiation. The highest risk, in the Z-Ditches, is from Am-241 and plutonium isotopes. Excavation workers, truck drivers, and waste management workers would be exposed to dose rates that require special protections. These protections would include shielding, high-efficiency particulate air filtration for breathing air, and equipment modification to provide additional shielding from the source. These precautions significantly increase costs; however, excavation with dust suppression and health and safety controls has been proven to handle potential problems with excavating large soil sites. Worker radiation doses for this alternative are very similar to Alternative 3, because most of the radioactivity is in the upper layers of soil. These doses, for the representative sites, are as follows.

216-U-10 Pond – The primary radionuclides of concern to remediation workers are Cs-137 and Co-60. The total cumulative radiation dose to all workers from implementing this alternative at the 216-U-10 Pond is estimated to be 1.4 rem.

216-U-14 Ditch – These sites are not candidates for Alternative 5.

216-Z-11 Ditch – These sites are not candidates for Alternative 5.

216-A-25 Pond – These sites are not candidates for Alternative 5.

216-T-26 Crib – The primary radionuclide of concern to remediation workers is Cs-137. The total cumulative radiation dose to all workers from implementing this alternative at the 216-T-26 Crib is estimated to be 0.6 rem.

These sites are not candidates for Alternative 5.

6.2.5.5.2 Impact to Environment during Remediation

Most of the short-term impacts to the environment from this alternative will be from the excavation phase of the work. Physical disruption of the waste sites during excavation, increased human activity and noise, in addition to the generation of fugitive dust, affect local biological resources. However, the waste sites are located within historically disturbed industrial areas.

216-U-10 Pond – The surface area disturbed during excavation and capping of this representative site and its analogous waste sites will be 61 ha (150 a). It is assumed that an additional 12 ha (30 a) will be disturbed from activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of 73 ha (180 a).

216-U-14 Ditch – As described earlier, these sites are not candidates for Alternative 5.

216-Z-11 Ditch – As described earlier, these sites are not candidates for Alternative 5.

216-A-25 Pond – As described earlier, these sites are not candidates for Alternative 5.

216-T-26 Crib – The only site in this group suitable for Alternative 5 is the 216-T-36 Crib. The surface area disturbed during excavation and capping of the 216-T-36 Crib will be 0.1 ha (0.2 a).

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to the ERDF and WIPP, and bringing clean fill to the excavated sites. Because the ERDF is located onsite, minimal uncertainties are associated with the transport of waste. Excavated soils with transuranic constituents above 100 nCi/g would be analyzed, treated, if necessary, and transported to the WIPP. The only waste currently identified in this FS as potentially requiring disposal to WIPP (e.g., greater than 100 nCi/g) is 2100 m^3 (2,700 yd^3) of soil beneath the 216-Z-11 Ditch and analogous Z-Ditches. Because these sites are not candidates for Alternative 5, the handling, transportation, and disposal of transuranic soils is not an issue for Alternative 5. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., waste or fill-material particulates) that could affect the public and the environment.

Alternative 5 may pose a significant short-term impact to the environment by disturbing areas of recovering habitat, such as the Gable Mountain Pond, where grasses are becoming more prevalent. While the deeper-rooted plants are currently controlled, the grasses do provide more habitat than unvegetated areas. Additionally, the disruptive nature of the removal process can have impacts on neighboring habitats and visiting wildlife, such as birds.

6.2.5.5.3 Time to Meet the Remedial Action Objectives

216-U-10 Pond – Design and construction of the partial removal, treatment, disposal, and capping alternative for this representative site would take approximately 7.4 years, based on the very conservative assumptions used in Appendix D. These assumptions include the use of two excavators working a 40-hour week, and an ERDF receipt limit of 336 m^3 (440 yd^3) per day. Once the contaminants are removed and the cap is installed, four of the five RAOs are met. The only RAO potentially not met is minimizing the general disruption of wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife. If analogous sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, and using the conservative assumptions discussed above, the time to remediate the analogous sites in this waste group would be an additional 24.4 years, for a total of 31.8 years.

216-U-14 Ditch – As described earlier, these sites are not candidates for Alternative 5.

216-Z-11 Ditch – As described earlier, these sites are not candidates for Alternative 5.

216-A-25 Pond – As described earlier, these sites are not candidates for Alternative 5.

216-T-26 Crib – The only site in this group suitable for Alternative 5 is the 216-T-36 Crib. The design and construction of the partial removal, treatment, disposal, and capping alternative for this site would take approximately 3.5 months. Once the contaminants are removed and the cap is installed, four of the five RAOs are met. The only RAO potentially not met is minimizing the general disruption of wildlife habitat. However, this waste site is located in an industrial setting, providing little habitat for vegetation and wildlife.

6.2.5.6 Implementability

The implementability of this alternative is similar to Alternatives 3 and 4. The excavation of contaminated soils is technically implementable, although the use of more sophisticated excavation equipment and techniques would be required for the high-dose areas. Every 0.3 m (1 ft) of excavation would require 0.5 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated, but is considered implementable. All excavated material would be disposed of at the onsite disposal facility (ERDF) or, if needed, at the WIPP. The current remaining capacity of ERDF is 7.65 million m^3 (as of February 6, 2004).

Construction of the caps would follow standard procedures that have been thoroughly field tested. The caps likely would require repair during the restoration timeframe. Monitoring the continued integrity of the caps would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the capping alternative would require additional design data (e.g., ground-penetrating radar) and possibly confirmatory sampling, because existing data may not be adequate for determining the lateral extent of the caps.

Gravel, sand, and silt/loam soil used for the caps would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix D. Area C currently is being evaluated as a silt borrow location; the area has a large volume of fine-grained material. Other locations have not yet been determined. Soil most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas. Analyses of an appropriate borrow area for silt/loam soil would be the subject of a future NEPA evaluation to determine a location with the least impacts to natural and cultural resources. Borrow material occurs in environmentally sensitive areas; obtaining sufficient capping material would affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the cap.

Limited coordination with other agencies and local governments would be necessary after approval of the alternative. Excavation and disposal would require coordination with state agencies to assess matters relative to storm water control and the potential for radioactive air emissions.

216-U-10 Pond and its Analogous Sites – These sites would be excavated to a depth of 4.6 m (15 ft). A total of 2 million m^3 (2.7 million yd^3) of contaminated soil will be removed from the 216-U-10 Pond and its analogous sites in this alternative (see Appendix D).

216-U-14 Ditch and its Analogous Sites – As described earlier, these sites are not candidates for Alternative 5.

216-Z-11 Ditch and its Analogous Sites – As described earlier, these sites are not candidates for Alternative 5.

216-A-25 Pond and its Analogous Site – As described earlier, these sites are not candidates for Alternative 5.

216-T-26 Crib and its Analogous Sites – The only site in this group suitable for Alternative 5 is the 216-T-36 Crib. This site would be excavated to a depth of 9.2 m (30 ft). A total of 1,300 m^3 (1,700 yd^3) of contaminated soil will be removed from this site in this alternative (see Appendix D). The 216-T-26 Pond is not included, as impacts from remediation of this site are included in another FS

If Alternative 5 were to be applied at the 216-U-10 Pond and 216-T-26 Crib, a total of 2 million m^3 (2.7 million yd^3) of soil would be disposed of at the ERDF. The current remaining capacity of ERDF is 7.65 million m^3 (as of February 6, 2004).

6.2.5.7 Cost

Costs, shown in Table 6-4, include stabilization of the existing site; excavation or import, transportation, and placement of material; compaction of the cap; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.2 percent discount rate (based on 2003 Office of Management and Budget information) and assumes operation and maintenance for the length of time needed to reach PRGs. The operation and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, and biotic control; maintenance of signs and markers; cover maintenance; and site reviews. Long-term monitoring costs associated with groundwater are not included in this cost estimate because contaminated groundwater in the 200 East Area will be addressed by the 200-BP-5 and 200-PO-1 groundwater OUs, and contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 OUs.

6.2.6 Detailed Analysis of Alternative 6 – In Situ Vitrification

This alternative is applicable to the 216-Z-11 Ditch representative waste site and the analogous Z-Ditches, only because of the high concentration of TRU radionuclides and a waste site configuration that is shallow and narrow (e.g., less than 20 ft deep and less than a 40 ft width).

More so than the other sites, this "long-narrow-shallow" configuration is potentially suitable for in situ vitrification (ISV). In comparison, the presence of high concentrations of TRU contaminants would make Alternative 3 relatively expensive (due to hauling, transportation, and disposal at WIPP).

As described in Chapter 4.0, ISV applies an electrical current to melt contaminated soil and forms a stable, vitrified mass when cooled. The stable mass chemically incorporates most inorganics (including heavy metals and radionuclides) and destroys or removes all organic contaminants. Convective mixing that occurs during vitrification will cause the contaminants to be mixed throughout the melt matrix.

Alternative 6 may require continuing institutional controls and monitoring to protect against intrusion and to verify that the design specifications for immobilization are met. Use of the ISV alternative for long-lived radioisotopes (specifically, TRU contamination in the Z-Ditches) must recognize that the effectiveness of institutional controls beyond 500 years is uncertain, and therefore it is important that the final waste form have long-term stability. Tests and natural analogs have shown vitrified waste to have such long-term stability.

This alternative has the potential to provide a high degree of overall protection of human health and the environment because contaminants are converted to a stable form with very low leachability. However, of the alternatives considered in this FS, ISV is the least technically proven for routine, large-scale application.

The following sections present a detailed analysis of Alternative 6 against the evaluation criteria. This analysis is summarized in Table 6-5.

6.2.6.1 Overall Protection of Human Health and the Environment

Alternative 6 is considered protective of human health and the environment for the Z-Ditches because it immobilizes the contaminants, preventing further migration. However, the risk assessment shows that the Z-Ditches have long-term human direct-contact and intruder risk. Placing the waste in a stable form will mitigate these risks but may not eliminate them. Therefore, a cap, similar to the cap used in Alternative 5, may be required to augment protectiveness. Because the direct-contact and intruder risks are caused by long-lived transuranics, doses will remain above acceptable levels for more than 1,000 years.

Because, under this alternative, the higher contaminant concentrations would be immobilized, failure of this alternative is not likely. Sampling would be performed to verify that the final waste form meets design specifications. Institutional controls may be required, and would include maintenance of the cap, land-use restrictions, and monitoring.

6.2.6.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 6 complies with ARARs by breaking exposure pathways. Contaminants are immobilized, preventing migration of treated waste through the vadose zone. If radiation doses in the 0 to 4.6 m (0- to 15-ft) zone are above PRGs, a cap similar in construction to the cap discussed for Alternative 5 may be required to meet ARARs. Groundwater protection standards are not exceeded at the Z-Ditches.

6.2.6.3 Long-Term Effectiveness and Permanence

Human Health

With regard to human health, this alternative would be effective and permanent in the long term because ISV activities under Alternative 6 would immobilize contaminants to meet intruder and direct exposure human health RAOs. To be effective in the long-term, a cap may be required if surface dose remains a problem after implementation of the alternative.

Groundwater Protection

Groundwater protection standards are not exceeded at the Z-Ditches.

The Environment

Alternative 6 would be protective at the selected sites because ISV would permanently bind the contamination into a glass matrix, which would result in low contaminant leaching potential. Penetration by burrowing animals would be unlikely; furthermore, the risk analysis (Chapter 2.0) shows that ecological risks at the Z-Ditches are negligible.

6.2.6.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 6 reduces toxicity and mobility by immobilizing contaminants and binding them into a glass-like matrix that has low contaminant leaching potential. During the vitrification process, the volume of contaminated soil generally is reduced by approximately 20 to 50 percent (EPA/540/R-94/520, *Geosafe Corporation In Situ Vitrification, Innovative Technology Evaluation Report*). Natural attenuation is an important treatment component of this alternative that results in the reduction of toxicity, mobility, and volume of the radionuclides. This alternative would rely on natural attenuation processes (most importantly radioactive decay), as well as immobilization of contaminants, to reduce radioactivity to levels that would not present a risk to human health or the environment.

6.2.6.5 Short-Term Effectiveness

6.2.6.5.1 Remediation Worker Risk

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 6, only minimal short-term risks are expected. The ISV alternative would not require excavation of contaminated soils, so the risks to workers primarily would be associated with general construction activities at the borrow sites and placement of the cap. Worker risk would be controlled through adherence to site health and safety procedures. Air monitoring would address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers. In addition, an offgas treatment system would be in continuous operation during ISV operations to collect, treat, and analyze airborne contaminants before release to the environment.

6.2.6.5.2 Impact to Environment During Remediation

Local biological resources would be affected by physical disruption of the waste sites during equipment mobilization, ISV operations, and demobilization. In addition, increased human activity and noise and the generation of fugitive dust affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. Approximately 5 ha (12 a) of surface area will be disturbed during implementation of this alternative at the Z-11 Ditch and analogous sites.

6.2.6.5.3 Time to Achieve the Remedial Action Objectives

This alternative mitigates the risk to human or ecological receptors by immobilizing the source. Based on calculations performed in Appendix D, construction and ISV activities would be expected to require 3.3 years to complete. The RAO for preventing unacceptable risk to human health and ecological receptors through exposure to contaminated soils and debris would be met.

6.2.6.6 Implementability

Of the six alternatives for remediation of the waste sites in this FS, Alternative 6 is the least used and least proven in routine field operations. ISV has been proven effective on similar sized sites, and major concerns have been satisfactorily resolved in these tests. Nonetheless, ISV is not used routinely for field remediation, so it must be considered to be an emerging, relatively unproven technology. For this reason, cost estimates, schedules, and effectiveness have a higher degree of uncertainty than is the case for other, more proven, alternatives.

6.2.6.7 Cost

Costs include mobilizing personnel and equipment; monitoring, sampling, and analysis; ISV operations; disposal of secondary waste (e.g., scrub liquid and high-efficiency particulate air filters); backfilling with onsite resources; procuring additional backfilling from a local stockpile; compacting the cap (if a cap is required); revegetating and stabilizing the site; and prime contractor oversight. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The cost estimate assumes that the subcontractor personnel are wearing Level D personal protective equipment (e.g., coveralls, no respirators) during ISV operations. The present-worth costs assume a 3.2 percent discount rate (based on current Office of Management and Budget information) and assumes operations and maintenance for a duration appropriate to the site contamination conditions. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, and biotic control, as needed; maintenance of signs and markers; cover maintenance; and site reviews. Long-term monitoring costs associated with groundwater are not included within this cost estimate because contaminated groundwater in the 200 East Area will be addressed by the 200-BP-5 and 200-PO-1 groundwater OUs, and contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 OUs.

Details of the cost estimates are presented in Appendix D. Summarized costs for the representative and analogous sites are presented in Table 6-5.

6.3 NEPA VALUES EVALUATION

The NEPA process is intended to help Federal agencies make decisions that are based on understanding environmental consequences, then to take actions that protect, restore, and enhance the environment. Secretarial policies (DOE 1994) and DOE O 451.1A require that CERCLA documents incorporate NEPA values, such as analysis of cumulative, offsite, ecological, and socioeconomic impacts to the extent practicable, in lieu of preparing separate NEPA documentation for CERCLA activities.

6.3.1 Description of NEPA Values

Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis frequently is directed at the potential effects of chemical contaminants on living organisms. The NEPA regulations (40 CFR 1502.16, "Environmental Impact Statement," "Environmental Consequences") specify evaluation of the environmental consequences of proposed alternatives. These include potential effects on transportation resources, air quality, and cultural and historical resources; noise; visual, and aesthetic effects; environmental justice; and the socioeconomic aspects of implementation. The NEPA process also involves consideration of several issues such as cumulative impacts (direct and indirect), mitigation of adversely impacted resources, and the irreversible and irretrievable commitment of resources.

The NEPA-related resources and values that the DOE has considered in this evaluation include the following.

- Transportation impacts. This value considers impacts of the proposed remedial action on local traffic (e.g., traffic at the Hanford Site) and traffic in the surrounding region. Transportation impacts are considered in part under the CERCLA criteria of short-term effectiveness or implementability.
- Air quality. This value considers potential air quality concerns associated with emissions generated during the proposed remedial actions.
- Natural, cultural, and historical resources. This value considers impacts of the proposed remedial actions on wildlife, wildlife habitat, archeological sites and artifacts, and historically significant properties on the Central Plateau.
- Noise, visual, and aesthetic effects. This value considers increases in noise levels or impaired visual or aesthetic values during or after the proposed remedial actions.
- Socioeconomic impacts. This value considers impacts pertaining to employment, income, other services (e.g., water and power utilities), and the effect of implementation of the proposed remedial actions on the availability of services and materials.
- Environmental justice. Environmental justice, as mandated by Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, refers to fair treatment of humans of all races, cultures, and income levels with respect to laws, policies, and government actions. This value

considers whether the proposed remedial actions would have inappropriately or disproportionately high and adverse human health or environmental effects on minority or low-income populations.

- Cumulative impacts (direct and indirect). This value considers whether the proposed remedial actions could have cumulative impacts on human health or the environment when considered together with other activities on the Central Plateau, at the Hanford Site, or in the region.

- Mitigation. If adverse impacts cannot be avoided, remedial action planning should minimize them to the extent practicable. This value identifies required mitigation activities.

- Irreversible and irretrievable commitment of resources. This value evaluates the use of nonrenewable resources for the proposed remedial actions and the effects that resource consumption would have on future generations. When a resource (e.g., energy, minerals, water, wetland) is used or destroyed and cannot be replaced within a reasonable amount of time, its use is considered irreversible.

6.3.2 Detailed Evaluation of NEPA

6.3.2.1 Transportation Impacts

Implementation of remedial action at the waste sites likely would have some short-term impacts on local traffic and traffic in the surrounding region. For Alternatives 4, 5, and 6, impacts would result from hauling cover material to the waste site areas. For Alternatives 3 and 5, these impacts would result from hauling waste to the ERDF and hauling clean fill to the waste sites. For Alternatives 3, 4, and 5, impacts could be expected from increased traffic bringing supplies, equipment, and workers to the sites. Alternative 6 also would include hauling ISV equipment to and from the ISV location. To mitigate these potential impacts, a transportation safety analysis would be performed before any transport activities began. The analysis would identify the need for specific precautions (e.g., road closures, preferred hauling times, staggered work shifts) to be taken as necessary. Increases in the workforce traffic related to waste treatment would be expected to be minor. The impacts of transportation of TRU waste to WIPP and disposal of TRU waste at WIPP were analyzed in DOE/EIS-0026-S-2, *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*.

For Alternatives 3 and 5, there may be a need to ship about 10,900 55-gal drums of TRU-contaminated soil to the WIPP, which would occur if a thin layer of soil beneath the 216-Z-11 Ditch is determined to have concentrations of TRU constituents greater than 100 nCi/g.

6.3.2.2 Air Quality

No current air quality impacts are associated with Alternative 1; however, potential impacts to air quality could be associated with plant or animal uptake of contaminants and wind dispersion. This also is true for Alternative 2. Potential near-term impacts to air quality associated with Alternatives 3, 4, and 5 are expected to be minor and could be mitigated through appropriate engineering controls. Alternative 6 includes an offgas treatment system, in operation during vitrification operations. Releases from the offgas treatment system would be subject to restrictions contained in a state air permit.

Potential air quality impacts primarily would be associated with fugitive dust during site preparation, structure demolition, excavation, placement of backfill or barriers, and revegetation activities. Dust suppression (using water and water treated with soil fixatives) would be used to control visible fugitive dust, so neither local nor regional air quality is expected to be affected. Routine emissions from vehicles would occur.

6.3.2.3 Natural, Cultural, and Historical Resources

In all cases, remediation will be performed on sites that have been disturbed by industrial activities. Therefore, although cultural resources could be encountered with Alternatives 3, 4, 5, and 6 during the excavation and construction of staging areas, the probability is low. A cultural resource mitigation plan would be established before remediation was begun. Known cultural resources and traditional-use areas would be avoided whenever possible. If cultural resources were encountered during excavation, the State Historic Preservation Office and Native American Tribes would be consulted about minimizing impacts and taking appropriate actions for resource documentation or recovery.

Some short-term adverse impacts to natural resources (e.g., local wildlife) could occur during the construction and implementation phases of remedial action. Ecological surveys would be performed to identify the species present and the special precautions that should be taken to minimize adverse impacts.

6.3.2.4 Noise, Visual, and Aesthetic Effects

Alternatives 1 and 2 would have little to no impact on current noise, visual, or aesthetic site characteristics. Alternatives 3 and 5 would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions and ultimately would improve the aesthetics by removing any remaining site structures. Likewise, Alternative 4 would increase noise levels and impair visual values in the short term during construction of the cap. These alternatives also could have some long-term visual and aesthetic impacts, both positive and negative. Positive impacts would result from the removal of aboveground site structures. Negative impacts would be associated with the visibility and aesthetics of the caps over large distances if they are not contoured to blend in with the surrounding area. Alternative 6 would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions. Aesthetically, given the past disturbance in the 200 Areas and on the Central Plateau, no impacts would be expected from the alternatives.

6.3.2.5 Socioeconomic Impacts

Alternative 1 would have no socioeconomic impacts. The other five alternatives would have some positive socioeconomic impacts related to the employment opportunities that would occur during the life of the remedial action project. The labor force required to implement remedial action would be drawn from current Hanford Site contractors and the local labor force, so the socioeconomic impacts would be expected to be minimal.

6.3.2.6 Environmental Justice

Under Alternative 3, environmental justice issues would not be a concern because future surface uses on the Central Plateau would not be restricted beyond the Central Plateau-wide restrictions. Under Alternatives 1, 2, 4, 5, and 6, environmental justice impacts would be minimal because future-use restrictions would pertain to only a small percentage of the Central Plateau, and the Central Plateau still would be under active waste management industrial land use.

6.3.2.7 Irreversible and Irretrievable Commitment of Resources

Alternatives 3, 4, 5, and 6 would require some irreversible or irretrievable commitment of natural resources. All of the alternatives with the exception of Alternative 1 would result in some land-use loss. Alternatives 3, 4, 5, and 6 would require additional soils, including materials that could come from ecologically sensitive areas, and some energy resources. They would require a commitment of resources in the form of land-use loss in the waste site areas until remedial action objectives and goals were met through the natural attenuation process. The amount of land-use loss would vary among alternatives. Alternative 2 generally would require land-use loss of the entire site surface and subsurface for the necessary attenuation period to meet remedial action objectives. Alternative 3 generally would allow land use from the ground surface to a depth of 4.6 m (15 ft) bgs or greater following the completion and regulatory acceptance of remedial activities. Alternatives 4, 5, and 6 would allow surface use of the sites, but would not allow any subsurface site use until the end of the necessary attenuation period to meet RAOs. This use would be limited based on potential impacts to surface-barrier integrity.

For Alternatives 3 and 5, the ERDF would need to be expanded to accommodate the additional waste. Implementation of the alternative also would require waste disposal to the WIPP. The waste volumes from the aboveground structure demolition in Alternatives 3, 4, 5, and 6 are relatively small and are not anticipated to specifically require additional ERDF capacity.

Alternatives 3, 4, 5, and 6 would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). With Alternatives 3 and 5, excavated material would be replaced with a stockpile of clean soil cover removed from the site, as well as clean sand and gravel fill from onsite borrow pits. The sand and gravel for the surface-barrier alternative would come from nearby borrow pits, but the silt would need to come either from the Fitzner-Eberhardt Arid Lands Ecology Reserve or from off site. Rip-rap or other armoring materials needed to provide intrusion protection likely would come from offsite. With Alternative 6, some fill material would be needed to compensate for the volume reduction inherent in the vitrification process.

6.3.2.8 Cumulative Impacts

The proposed RAOs could have impacts when considered together with impacts from past and foreseeable future actions at and near the Hanford Site. Authorized current and future activities include soil and groundwater remediation; waste management and treatment (e.g., tank farms, the Waste Treatment Plant); and surveillance, maintenance, decontamination, and decommissioning of facilities. Other Hanford Site activities that might be ongoing during remedial action at the Central Plateau waste sites include deactivation and decontamination of reprocessing facilities and operation of the Energy Northwest reactor. Activities near the

Hanford Site include a privately owned radioactive and mixed waste treatment facility, a commercial fuel manufacturer, a commercial low-level radioactive waste disposal site, and a titanium reprocessing plant.

The proposed remediation alternatives would have minimal impacts on transportation, air quality, and natural, cultural, and historical resources. Noise, visual and aesthetic effects, and socioeconomic impacts also would be minimal. Therefore, cumulative impacts with respect to these values are expected to be insignificant. The most notable area for cumulative impacts is with respect to the irretrievable and irreversible commitment of resources. All of the proposed alternatives except Alternative 1 would require long-term land-use restrictions.

To varying levels, Alternatives 2, 3, 4, 5, and 6 would result in the loss of some land uses on the Central Plateau, but the cumulative impacts with respect to loss of land use are not expected to be significant. Alternatives 3 and 5 also would require a commitment of land use as a result of the ERDF expansion on the Central Plateau. This would be in addition to numerous other Hanford Site projects that would commit land use on the Central Plateau.

Under Alternatives 3, 4, 5, and 6, cumulative impacts also would occur with respect to the irretrievable and irreversible commitment of geologic resources. The Central Plateau waste sites constitute only a portion of the total actions requiring material for barriers and backfill at the Hanford Site. The total quantity of geologic materials required for other Hanford Site actions currently is being identified (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) and may be subject to a separate NEPA evaluation.

6.3.2.9 Mitigation

Alternative 1 would not include mitigation. Mitigation measures under Alternatives 2 and 6 would include surveillance, physical controls, and potential interim remedies. Mitigation measures taken under Alternatives 3, 4, and 5 would include dust suppression, stockpiling clean topsoil for reuse, minimizing the size of construction areas, and planning activities to avoid nesting and breeding cycles of birds and mammals.

6.3.2.10 Summary of NEPA Evaluation

Remedial actions at the Central Plateau waste sites would result in some impacts to public health and the environment. However, the overall environmental impacts under normal operating conditions would not be very large, nor would they vary greatly among the remedial alternatives.

6.4 REFERENCES

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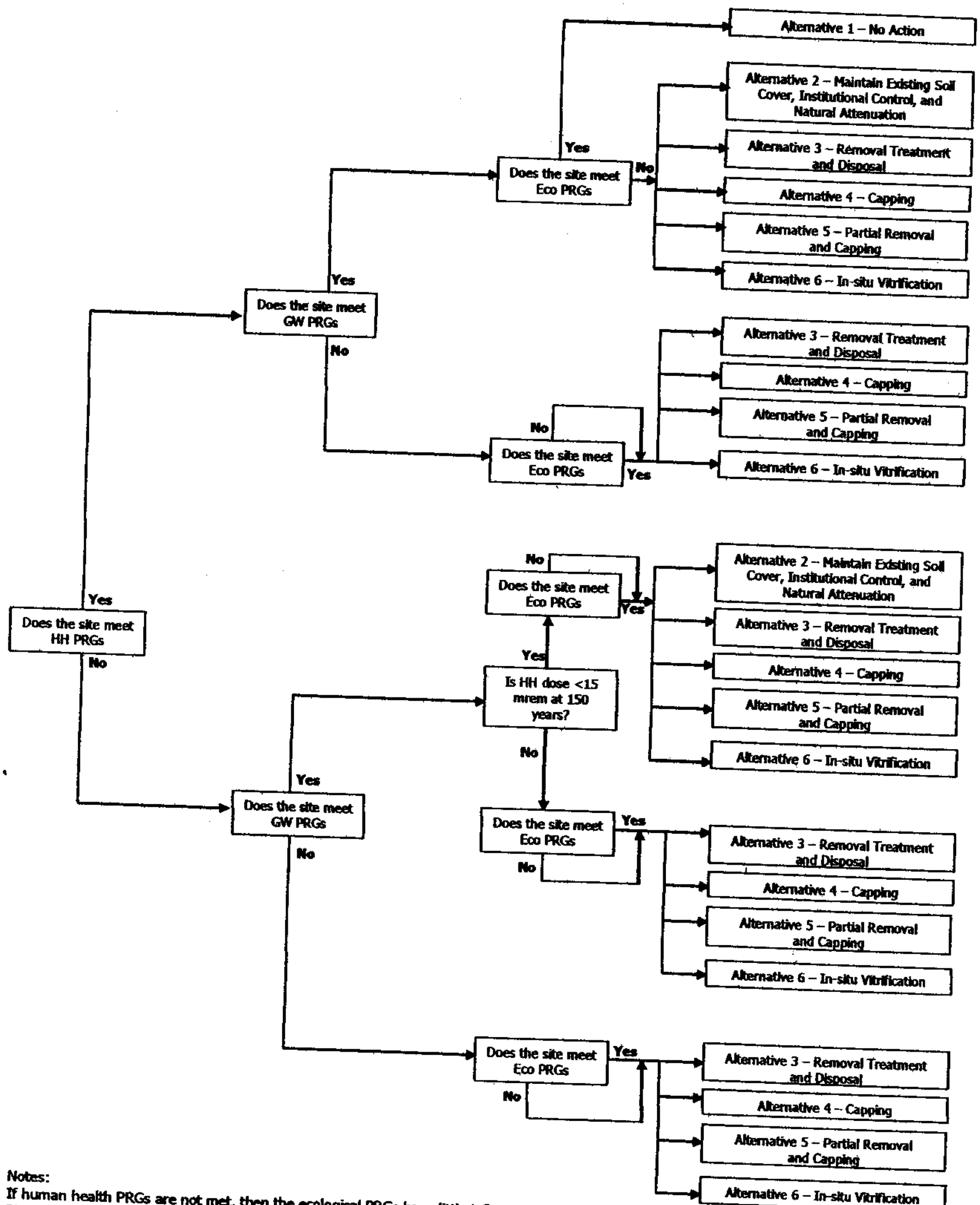
Figure 6-1. Logic Diagram for Selecting Applicable Alternatives.



Notes:
If human health PRGs are not met, then the ecological PRGs have little influence on the alternatives.
If human health PRGs are met, then the ecological PRGs have a significant influence on the alternatives.

ECO = Ecological GW= Groundwater HH = Human Health mrem = Millrem PRG = Preliminary Remediation Goals < = Less Than

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	**Threshold Criteria**		**Balancing Criteria**				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
Representative Site							
216-U-10 Pond	Not protective because contaminants remain above PRGs after 500 years.	Does not comply.	Groundwater is not protected. Potential risks to burrowing animals exist.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$13,765
Waste Sites Analogous to 216-U-10 Pond							
216-S-16P Pond	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Groundwater is not protected. Potential risks to burrowing animals exist.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$14,158
Group consisting of 216-S-17 Pond and UPR-W-124 Unplanned Release	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was significantly less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Groundwater is not protected. Potential risks to burrowing animals exist.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$12,146

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
216-T-4A Pond	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$11532
216-T-4B Pond	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,391
216-U-9 Ditch	Based on 216-U-10 Pond data, not anticipated to be protective. However, underlying soils may be less contaminated because ditches used to channel wastewater may result in limited infiltration of contaminants.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$915

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
216-U-11 Ditch	Based on 216-U-10 Pond data, not anticipated to be protective. However, underlying soils may be less contaminated because ditches used to channel wastewater may result in limited infiltration of contaminants.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,043
216-S-5 Crib	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,096
216-S-6 Crib	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,096

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Group consisting of 216-A-6, UPR-200-E-19, UPR-200-E-21, and UPR-200-E-29	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$821
216-A-30 Crib	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$815
216-S-25 Crib	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$4,752
216-A-37-2 Crib	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$815

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
216-B-55 Crib	Based on 216-U-10 Pond data, not anticipated to be protective. However, the effluent volume received was less than the 216-U-10 Pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$771
216-S-172 Control Structure	Based on 216-U-10 Pond data, not anticipated to be protective. However, underlying contamination may be less significant because the sites consist of concrete-lined structures versus an unlined pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$746
2904-S-160 Control Structure	Based on 216-U-10 Pond data, not anticipated to be protective. However, underlying contamination may be less significant because the sites consist of concrete-lined structures versus an unlined pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$746

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
2904-S-170 Control Structure	Based on 216-U-10 Pond data, not anticipated to be protective. However, underlying contamination may be less significant because the sites consist of concrete-lined structures versus an unlined pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$730
2904-S-171 Control Structure	Based on 216-U-10 Pond data, not anticipated to be protective. However, underlying contamination may be less significant because the sites consist of concrete-lined structures versus an unlined pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$746

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
207-S Retention Basin	Based on 216-U-10 Pond data, not anticipated to be protective. However, there is no documented evidence that the basin has leaked. Furthermore, underlying contamination may be less significant because the basin is a concrete-lined structure versus an unlined pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$877
216-B-64 Retention Basin	Expected to be protective. The basin was built for emergency runoff but never used. Only loose surface contamination eroded from UPR-200-E-64 is present.	Expected to comply.	Expected to be effective.	Reduction of residual contamination through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$769

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
200-E-113 Process Sewer	Based on 216-U-10 Pond data, not anticipated to be protective. However, underlying contamination may be less significant because the site consists of steel pipeline versus an unlined pond.	Based on 216-U-10 data, anticipated to not comply.	Based on 216-U-10 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$726
Representative Site							
216-U-14 Ditch	Protective because contaminants are within dose and risk guidelines within 500 years.	Does not comply.	Groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$918
Waste Sites Analogous to 216-U-14 Ditch							
216-S-16D Ditch	Protective because contaminants are within dose and risk guidelines within 500 years.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$789

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-T-1 Ditch	Protective because contaminants are within dose and risk guidelines within 500 years.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$738
Group consisting of 216-T-4-1D and 216-T-4-2	Protective because contaminants are within dose and risk guidelines within 500 years.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$882
216-W-LWC Crib	Protective because contaminants are within dose and risk guidelines within 500 years.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,510

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Group consisting of 207-U Retention Basin, UPR-200-W-111, and UPR-200-W-112	Protective because contaminants are within dose and risk guidelines within 500 years.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,072
207-T Retention Basin	Protective because contaminants are within dose and risk guidelines within 500 years.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$952
216-T-12 Trench	Protective because contaminants are within dose and risk guidelines within 500 years.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$725

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
200-W-84 Process Sewer	Protective because contaminants are within dose and risk guidelines within 500 years. Underlying contamination may be less significant because the sewer consists of a vitrified clay pipe versus an unlined ditch. Waste site configuration suggests that infiltration is limited.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$742
200-W-88 Process Sewer	Protective because contaminants are within dose and risk guidelines within 500 years. Underlying contamination may be less significant because the sewer consists of a vitrified clay pipe versus an unlined ditch.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$862

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
200-W-102 Process Sewer	Protective because contaminants are within dose and risk guidelines within 500 years. Underlying contamination may be less significant because the sewer consists of a vitrified clay pipe versus an unlined ditch. Waste site configuration suggests that infiltration is limited.	Based on 216-U-14 data, anticipated to not comply.	Based on 216-U-14 data, groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$738
Representative Site							
Representative Site 216-Z-11 Ditch Part of Group consisting of 216-Z-1D and 216-Z-19 Ditches 216-Z-20 Crib, and UPR-200-W-110	Not protective because contaminants remain above PRGs after 500 years.	Does not comply.	Not effective. Contaminant concentra-tions are high and will remain elevated past 500 years; institutional controls may not be protective past 500 years.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,593

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Waste Sites Analogous to 216-Z-11 Ditch							
207-Z Retention Basin	Based on 216-Z-11 data, not anticipated to be protective; however, underlying contamination may be less significant because the basin is a concrete-lined structure versus an unlined pond.	Based on 216-Z-11 data, anticipated to not comply.	Based on 216-Z-11 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$741
Representative Site							
216-A-25 Gable Mountain Pond	Protective because ELCR and exposure guidelines meet at approximately 150 years.	Does not comply.	Protective due to natural attenuation of radioactive contaminants in approximately 150 years.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	N/A (covered in a separate FS)

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Waste Sites Analogous to 216-A-25 Gable Mountain Pond							
207-A North Retention Pond	Based on 216-A-25 data, not anticipated to be protective. Furthermore, there is no evidence of leakage to date. Underlying contamination may be less significant or not present because the retention pond is a Hypalon*-lined concrete structure versus an unlined pond. Lastly, the geology is significantly different from the 216-A-25 Pond.	Based on 216-A-25 data, anticipated to not comply. However, would comply if verification sampling indicated residual contamination is present.	Based on 216-A-25 data, anticipated to not be effective. However, would be effective if verification sampling indicated residual contamination is present.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$748
Representative Site							
216-T-26 Crib	Not protective because contaminants remain above PRGs after 500 years.	Does not comply.	Groundwater is not protected.	Reduction through natural attenuation of radionuclides	No short-term risks to workers; no ecological risks expected contaminants are greater than 4.6 m (15 ft) bgs.	Readily implementable.	N/A (covered in a separate FS)

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (15 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Waste Sites Analogous to 216-T-26 Crib							
216-T-36 Crib	Based on 216-T-26 data, not anticipated to be protective. However, the contaminant inventory and small amount of discharge suggests a low potential effect to groundwater.	Based on 216-T-26 data, anticipated to not comply.	Based on 216-T-26 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$727
200-W-79 Pipeline	Based on 216-T-26 data, not anticipated to be protective. However, underlying contamination may be less significant because the pipeline is a vitrified clay pipe versus an unlined crib. Waste site configuration suggests that infiltration is limited.	Based on 216-T-26 data, anticipated to not comply.	Based on 216-T-26 data, anticipated to not be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$729

*Hypalon is a registered trademark of Dupont Dow Elastomers Limited Liability Company, Wilmington, Delaware.

ARAR = applicable or relevant and appropriate requirement.
BGS = below ground surface.
PRG = preliminary remediation goal.

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Representative Site							
216-U-10 Pond	Protective. Excavation would remove 210 ft of contaminants. Would eliminate direct contact with human and ecological receptors.	Complies.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, protection of groundwater, and the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. High possibility of impacting biological and/or cultural resources due to excavation to 210 ft.	Excavation to 210 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs. More than 40 million yd^3 would be disposed at ERDF for this representative site and all its associated analogous sites, 10 million yd^3 for 216-U-10 alone. Implementability is questionable because of area (72 acres) and depth of the excavation and available capacity at the ERDF.	$1,811,601
Waste Sites Analogous to 216-U-10 Pond							
216-S-16P Pond	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs. More than 10 million yd^3 would be disposed at ERDF for this site. Implementability is questionable because of area (73 acres) and depth of the excavation and available capacity at the ERDF.	$1,869,572

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
Group consisting of 216-S-17 Pond and UPR-W-124 Unplanned Release	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs. Over 7 million yd^3 would be disposed at ERDF for this site.	$1,338,773
216-T-4A Pond	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs. More than 8 million yd^3 would be disposed at ERDF for this site.	$1,581,528

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-T-4B Pond	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs.	$219,204
216-U-9 Ditch	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs.	$554,350
216-U-11 Ditch	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs.	$699,278

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-S-5 Crib	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs.	$182,972
216-S-6 Crib	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs.	$182,972

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Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-A-30 Crib	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs. Additionally, excavation would extend into the vitrification plant construction zone.	$277,175
216-S-25 Crib	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs. Additionally, excavation would extend into adjacent small buildings and the 214-AP Tank Farm.	$592,393
216-A-37-2 Crib	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs. Excavation would extend into the Waste Vitrification Plant construction area's southwest corner.	$277,175

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-B-55 Crib	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementability is questionable because excavation to 200 ft is necessary to remove all contaminants (to the water table), necessary to meet PRGs.	$186,595
216-S-172 Control Structure	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$238
2904-S-160 Control Structure	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$238

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
2904-S-170 Control Structure	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$238
2904-S-171 Control Structure	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$238
207-S Retention Basin	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$2,510

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
216-B-64 Retention Basin	Expected to be protective. The basin was built for emergency runoff but never used. Only loose surface contamination eroded from UPR-200-E-64 is present.	Anticipated to comply.	Anticipated to be effective.	Reduction of residual contamination through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,044
200-E-113 Process Sewer	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, excavation to 200 ft would impact PUREX buildings.	$467
Representative Site							
216-U-14 Ditch	Protective. Excavation would remove 15 ft of contaminants. Would eliminate direct contact with human and ecological receptors.	Complies.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed and potential worker radiation exposure is low. High possibility of impacting biological and/or cultural resources due to excavation.	Excavation to 15 ft is necessary to remove all contaminants to PRGs. A total of 64,000 yd^3 would be disposed at ERDF for this representative site and all its associated analogous sites. Available capacity at the ERDF may be an issue.	$3,702

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Waste Sites Analogous to 216-U-14 Ditch							
216-S-16D Ditch	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$1,363
216-T-1 Ditch	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$977

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Group consisting of 216-T-4-1D and 216-T-4-2 Ditches	Anticipated to be protective. Most of the effluent in the 216-T-4-2 Ditch was absorbed in the first quarter of the ditch; therefore, the end of the ditch was often dry. Waste site configuration suggests shallow contamination.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given site configuration, it is likely that contamination (if any) is shallow and that the alternative would comply with ARARs.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$3,243
216-W-LWC Crib	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$2,588
Group consisting of 207-U Retention Basin, UPR-200-W-111, and UPR-200-W-112	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$4,362

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	**Threshold Criteria**		**Balancing Criteria**				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
207-T Retention Basin	Anticipated to be protective. Waste site configuration suggests shallow contamination because the basin is a concrete-lined structure versus an unlined pond.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given site configuration and limited evidence of leakage, it is likely that contamination (if any) is shallow and the alternative would comply with ARARs.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$4,180
216-T-12 Trench	Anticipated to be protective. Waste consists of sludge deposited in 207-T Retention Basin.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given site characteristics, it is likely that contamination (if any) is shallow and that the alternative would comply with ARARs.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$238

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
200-W-84 Process Sewer	Anticipated to be protective. Waste site configuration suggests shallow contamination because the sewer consists of a vitrified clay pipe versus an unlined ditch.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given site characteristics, it is likely that contamination (if any) is shallow and that the alternative would comply with ARARs.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$238
200-W-88 Process Sewer	Would be protective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, excavation would extend to miscellaneous underground storage tank 241-T-361.	$2,536
200-W-102 Process Sewer	Anticipated to be protective. Waste site configuration suggests shallow contamination because the sewer consists of a vitrified clay pipe versus an unlined ditch.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given site characteristics, it is likely that contamination (if any) is shallow and that the alternative would comply with ARARs.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, removes potential groundwater contaminants, and protects the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$981

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	**Threshold Criteria**		**Balancing Criteria**				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
Representative Site							
Representative Sites 216-Z-11 Ditch Part of Group consisting of 216-Z-1D, 216-Z-19 ditches, 216-Z-20 crib, and UPR-200-W-110	Would be effective. Excavation expected to remove all contaminants to PRGs. Would eliminate direct contact with human and ecological receptors and transport of contaminants to groundwater.	Complies.	Would be effective. Contaminant concentrations are removed to meet PRGs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Due to high transuranic concentrations in the 216-Z-11-Ditch, extremely high short-term risks to workers would exist; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Excavation to 15 ft is necessary to remove all contaminants to PRGs. Approximately 36,000 yd^3 would be disposed at ERDF and 2,700 yd^3 at the WIPP for this rep. site and all its analogous sites. Higher dose rates on packaged waste likely will affect worker radiation exposure. Available capacity at the ERDF may be an issue.	$77,501
Waste Sites Analogous to 216-Z-11 Ditch							
207-Z Retention Basin	Anticipated to be protective. Waste site configuration suggests shallow contamination because the basin is a concrete-lined structure versus an unlined pond.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given site configuration and limited evidence of leakage, it is likely that contamination (if any) is shallow and that the alternative would comply with ARARs.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given available data, it is likely that contamination would be removed to PRGs and that the alternative would be highly effective.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$296

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
Representative Site							
216-A-25 Gable Mountain Pond	Would be effective. Excavation expected to remove all contaminants to PRGs. Would eliminate direct contact with human and ecological receptors and transport of contaminants to groundwater.	Complies.	Would be effective. Contaminant concentrations are removed to meet PRGs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Excavation to 15 ft is necessary to remove all contaminants to PRGs.	N/A (covered in a separate FS)
Waste Sites Analogous to 216-A-25 Gable Mountain Pond							
207-A North Retention Pond	Anticipated to be protective. Waste site configuration suggests shallow contamination because the retention pond is a Hypalon*-lined concrete structure versus an unlined pond.	Complies.	Would be effective. Contaminant concentrations are removed to meet PRGs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable.	$247

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
Representative Site							
216-T-26 Crib	Protective. Excavation would remove 200 ft of contaminants. Would eliminate direct contact with human and ecological receptors.	Complies.	Effective and permanent in the long term because excavation removes contaminants to meet human health RAOs, protection of groundwater, and the environment.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed. High possibility of impacting biological and/or cultural resources due to excavation to 200 ft.	Excavation at this site is impractical due to the location of the 216-T-27 and 216-T-28.	N/A (covered in a separate FS)
Waste Sites Analogous to 216-T-26 Crib							
216-T-36 Crib	Anticipated to be protective. Contaminant inventory and small amount of discharge suggests a low potential effect to groundwater. Waste site configuration suggests shallow contamina-tion.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given site characteristics, it is likely that contamination (if any) is shallow and that the alternative would comply with ARARs.	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given available data, it is likely that contamination would be removed to PRGs and that the alternative would be highly effective.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$37,736

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (16 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
200-W-79 Pipeline	Anticipated to be protective. Waste site configuration suggests shallow contamination because the sewer consists of a vitrified clay pipe.	Would comply if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given site characteristics, it is likely that contamination (if any) is shallow and that the alternative would comply with ARARs	Would be effective if all contaminants could be excavated to PRGs and disposed at an appropriate disposal facility. Given available data, it is likely that contamination would be removed to PRGs and that the alternative would be highly effective.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term risks to workers; ecological risks not expected because contaminants are removed.	Implementable.	$238

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ARAR = applicable or relevant and appropriate requirement.
ERDF = Environmental Restoration Disposal Facility.
FS = feasibility study.
N/A = not applicable.
PRG = preliminary remediation goal.
PUREX = Plutonium-Uranium Extraction Plant.
RAO = remedial action objective.
WIPP = Waste Isolation Pilot Plant.

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost In Thousands
Representative Site							
216-U-10 Pond	Protective. This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. PRGs for this site are reached in approxi-mately 280 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$46,064
Waste Sites Analogous to 216-U-10 Pond							
216-S-16P Pond	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$47,629
Group consisting of 216-S-17 Pond and UPR-W-124 Unplanned Release	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$32,389

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost In Thousands
216-T-4A Pond	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$38,091
216-T-4B Pond	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$2,330
216-U-9 Ditch	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$777

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost In Thousands
216-U-11 Ditch	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,329
216-S-5 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,605
216-S-6 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,605

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost In Thousands**
Group consisting of 216-A-6, UPR-200-E-19, UPR-200-E-21, and UPR-200-E-29	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$729
216-A-30 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$677
216-S-25 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$11,684

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost In Thousands**
216-A-37-2 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$677
216-B-55 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$682
216-S-172 Control Structure	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$702

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost In Thousands
2904-S-160 Control Structure	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$702
2904-S-170 Control Structure	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$686
2904-S-171 Control Structure	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$702

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost In Thousands**
207-S Retention Basin	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$702
216-B-64 Retention Basin	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Anticipated to be effective.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$682
200-E-113 Process Sewer	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$677

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost In Thousands**
Representative Site							
216-U-14 Ditch	Would be protective. This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. PRGs for this site are reached in approximately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$17,497
Waste Sites Analogous to 216-U-14 Ditch							
216-S-16D Ditch	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approximately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$5,260
216-T-1 Ditch	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approximately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$4,230

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost In Thousands
Group consisting of 216-T-4-1D and 216-T-4-2 Ditches	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approximately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$16,012
216-W-LWC Laundry Waste Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approximately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$61,333
Group consisting of 207-U Retention Basin, UPR-W-111, and UPR-W-112 Unplanned Releases	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approximately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$28,035

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost In Thousands**
207-T Retention Basin	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approxi-mately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$23,276
216-T-12 Trench	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approxi-mately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$681
200-W-84 Process Sewer	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approxi-mately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$3,049

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost In Thousands
200-W-88 Process Sewer	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approxi-mately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$15,888
200-W-102 Process Sewer	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. Based on 216-U-14, PRGs for this site are reached in approxi-mately 470 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$4,475
Representative Site							
Representative Sites 216-Z-11 Ditch Part of Group ABAR2W10 consisting of 216-Z-1D, 216-Z-19, 216-Z-20, and UPR-200-W-110, and 216-Z-20	Would be moderately protective. Although, in the short term, this alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion, integrity of the cap can not be ensured past 1,000 years.	Complies with ARARs because the barrier is in place.	Would be partially effective. Hanford-type barrier is protective to 1,000 years. Transuranic concentra-tions would remain for greater than this time period.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$42,237

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost In Thousands
Waste Sites Analogous to 216-Z-11 Ditch							
207-Z Retention Basin	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$3,761
Representative Site							
216-A-25 Gable Mountain Pond	Would be protective. This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective. Modified RCRA C-type barrier is protective to 500 years. PRGs for this site are within this time frame.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	N/A (covered in a separate FS)
Waste Sites Analogous to 216-A-25 Gable Mountain Pond							
207-A North Retention Pond	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$702

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost In Thousands**
Representative Site							
216-T-26 Crib	Would be protective. This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	N/A (covered in a separate FS)
Waste Sites Analogous to 216-T-26 Crib							
216-T-36 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$3,004

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (14 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost In Thousands**
200-W-79 Pipeline	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Would be effective if contaminants degraded within 1,000 years. Modified RCRA C-type barrier is protective to 500 years and Hanford-type barrier to 1,000 years.	Reduction through natural attenuation of radionuclides.	Limited short-term risks to workers; no ecological risks expected, site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$685

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

ARAR = applicable or relevant and appropriate requirement.
PRG = preliminary remediation goal.
RCRA = *Resource Conservation and Recovery Act of 1976.*

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Representative Site							
216-U-10 Pond	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. The most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term radiological risks to workers (1.4 rem); ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	More than 2.7 million yd^3 would be disposed at ERDF for this representative site and all its associated analogous sites. Implementability may be questionable because available capacity at the ERDF may be an issue.	$130,523
Waste Sites Analogous to 216-U-10 Pond							
216-S-16P Pond	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$137,569

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Group consisting of 216-S-17 Pond and UPR-W-124 Unplanned Release	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$93,637
216-T-4A Pond	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$110,287

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-T-4B Pond	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$7,075
216-U-9 Ditch	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$4,085

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
216-U-11 Ditch	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$6,173
216-S-5 Crib	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$4,738

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-S-6 Crib	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$4,738
Group consisting of 216-A-6, UPR-200-E-19, UPR-200-E-21, and UPR-200-E-29	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	1,241

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-A-30 Crib	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$2,234
216-S-25 Crib	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$34,096

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-A-37-2 Crib	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$2,234
216-B-55 Crib	Protective Excavation would remove 15 ft of contaminants to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because the soil barrier is in place and direct contact with human and ecological receptors is removed.	This alternative would be partially effective. Although the most highly contaminated soils would be excavated, some chemicals and radionuclides are left in place. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term risks to workers; ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources due to the large excavation area.	Implementable; however, available capacity at the ERDF may be an issue. Source of fine grain capping materials has not been identified.	$1,325
216-S-172 Control Structure	N/A. Contamination anticipated to be shallow at this site.	N/A	N/A	N/A	N/A	N/A	N/A
2904-S-160 Control Structure	N/A. Contamination anticipated to be shallow at this site.	N/A	N/A	N/A	N/A	N/A	N/A

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
2904-S-170 Control Structure	N/A. Contamination anticipated to be shallow at this site.	N/A	N/A	N/A	N/A	N/A	N/A
2904-S-171 Control Structure	N/A. Contamination anticipated to be shallow at this site.	N/A	N/A	N/A	N/A	N/A	N/A
207-S Retention Basin	N/A. Contamination anticipated to be shallow at this site.	N/A	N/A	N/A	N/A	N/A	N/A
216-B-64 Retention Basin	N/A. Contamination anticipated to be shallow at this site.	N/A	N/A	N/A	N/A	N/A	N/A
200-E-113 Process Sewer	N/A. Contamination anticipated to be shallow at this site.	N/A	N/A	N/A	N/A	N/A	N/A
Representative Site							
216-U-14 Ditch	The 216-U-14 Ditch and its analogous sites are not applicable under Alternative 5 because contaminants are in the top 15 ft.	N/A	N/A	N/A	N/A	N/A	N/A

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Waste Sites Analogous to 216-U-14 Ditch							
216-S-16D Ditch	N//A	N/A	N/A	N/A	N/A	N/A	N/A
216-T-1 Ditch	N//A	N/A	N/A	N/A	N/A	N/A	N/A
Group consisting of 216-T-4-1D and 216-T-4-2 Ditches	N/A	N/A	N/A	N/A	N/A	N/A	N/A
216-W-LWC Crib	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Group consisting of 207-U Retention Basin, UPR-W-111 and 200-W-112 Unplanned Releases	N/A	N/A	N/A	N/A	N/A	N/A	N/A
207-T Retention Basin	N/A	N/A	N/A	N/A	N/A	N/A	N/A
216-T-12 Trench	N/A	N/A	N/A	N/A	N/A	N/A	N/A
200-W-84 Process Sewer	N/A	N/A	N/A	N/A	N/A	N/A	N/A
200-W-88 Process Sewer	N/A	N/A	N/A	N/A	N/A	N/A	N/A
200-W-102 Process Sewer	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Representative Site							
Representative Sites 216-Z-11 Ditch Part of Group ABAR2W10 consisting of 216-Z-1D, 216-Z-19, 216-Z-20, and UPR-200-W-110, and 216-Z-20	The 216-Z-11 Ditch and its analogous sites are not applicable under Alternative 5 because, when contaminants are removed to 15 ft, a cap is not necessary.	N/A	N/A	N/A	N/A	N/A	N/A
Waste Sites Analogous to 216-Z-11 Ditch							
207-Z Retention Basin	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Representative Site							
216-A-25 Gable Mountain Pond	The 216-A-25 Pond and its analogous sites are not applicable under Alternative 5 because, when contaminants are removed to 15 ft, a cap is not necessary.	N/A	N/A	N/A	N/A	N/A	N/A
Waste Sites Analogous to 216-A-25 Gable Mountain Pond							
207-A North Retention Pond	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Representative Site							
216-T-26 Crib	Partially protective. Excavation would remove contaminants to 30 ft to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs by breaking exposure pathways and emplacing caps that meet intent of groundwater protection regulations. Institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative.	This alternative would be partially effective. Direct contact with human and ecological receptors is removed. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term industrial and radiological risks to workers (0.6 rem); ecological risks not expected because contaminants are removed. Possibility of impacting biological and/or cultural resources due to the size of excavation area.	Implementable; however, source of fine grain capping materials has not been identified.	N/A (covered in a separate FS)

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (11 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
			Waste Sites Analogous to 216-T-26 Crib				
216-T-36 Crib	Protective. Excavation would remove contaminants to 30 ft to eliminate direct contact with human and ecological receptors. Caps will be designed to reduce infiltration and protect groundwater over the lifetime of the cap.	Complies with ARARs because of institutional controls and the soil barrier is in place.	This alternative would be effective. Direct contact with human and ecological receptors is removed. Caps will be designed to reduce infiltration.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Short-term industrial and radiological risks to workers; ecological risks not expected because contaminants are removed. Possibility of impacting biological and/or cultural resources due to the size of excavation area.	Implementable; however, source of fine grain capping materials has not been identified.	$3,455
200-W-79 Pipeline	N/A	N/A	N/A	N/A	N/A	N/A	N/A

ARAR = applicable or relevant and appropriate requirement.
ERDF = Environmental Restoration Disposal Facility.
N/A = not applicable.
PRG = preliminary remediation goal.

Table 6-5. Detailed Analysis Summary for Alternative 6 – In Situ Vitrification.

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost In Thousands**
			Representative Site				
Representative Sites 216-Z-11 Ditch Part of Group consisting of 216-Z-1D, 216-Z-19, ditches 216-Z-20, crib and UPR-200-W-110 NOTE: ISV is only applicable for the waste sites listed above and is included because of the high TRU concentration present, and 216-Z-20.	Protective. ISV would mitigate groundwater risk because the treated soil would be in a non-leachable waste form. The extent to which ISV will mitigate direct radiation doses at the site is uncertain. It may be necessary to cap the site following ISV to decrease exposure to Cs-137. Long-term controls may be necessary to prevent intrusion.	Complies with ARARs because the waste is immobilized.	This alternative would be effective. The most highly contaminated soils would be immobilized. A soil cover would be placed over the vitrified waste to prevent intrusion. ISV is an innovative technology; consequently, its effectiveness has not been widely demonstrated.	This alternative employs treatment where the waste is converted to a form that is highly resistant to erosion.	Limited short-term risks to workers; no ecological risks expected.	ISV is an innovative technology; consequently, its implementability has not been widely demonstrated.	$93,567

ARAR = applicable or relevant and appropriate requirement.
ISV = in situ vitrification.

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